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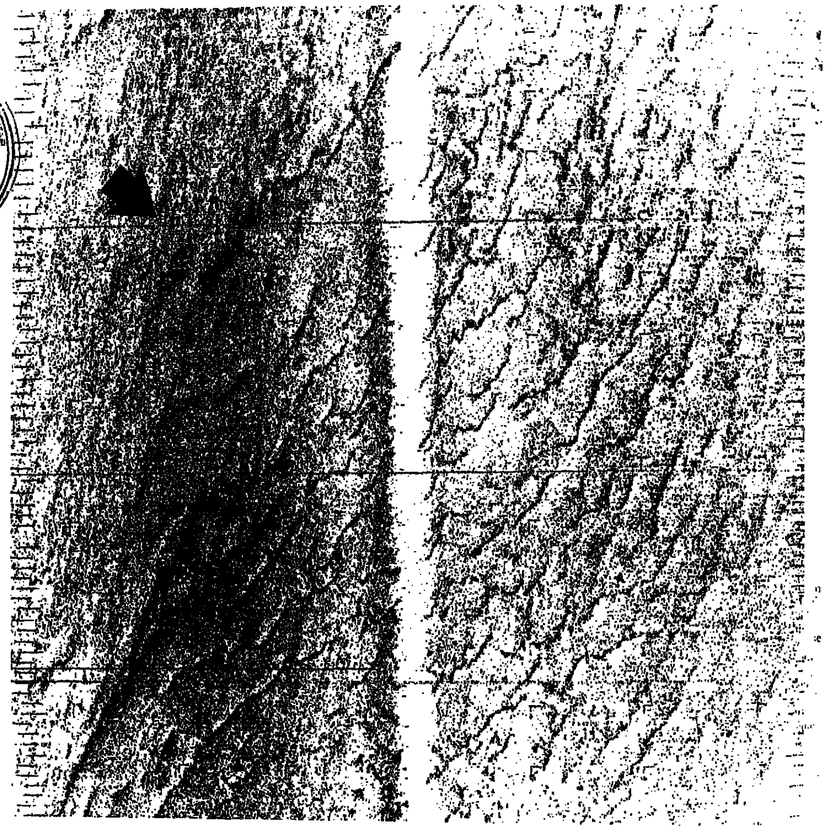

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Vol. 64, No. 22, Pages 393–400

News

Subangstrom Microscopy

Materials scientists, solid state geophysicists, geochemists, and mineralogists are becoming increasingly interested in examining surfaces of crystals at ultrahigh resolution. Modern scanning transmission electron microscopy (STEM) techniques have resolution of better than 10^{-8} m (100 Å) a requirement for studying microresolution features in crystals. Electron microscopy and microprobe/microdiffraction techniques have become standard in the examination of surface features of polished crystals. There remain numerous features, atomic clusters, lattice point crystals and defect phenomena that have not been resolved, but which will be amenable to the newly invented scanning tunneling microscopy methods.

Recent work reported by the IBM Research Laboratory in Zurich includes scanning electron tunneling measurements of surfaces in which the vertical resolution achieved was better than 10^{-11} m, the horizontal resolution being about 6×10^{-10} m (about two large atomic diameters). The image buildup from successive scanning rasters results from the vertically resolved relief. Unlike electron microscopy and other scanning techniques (such as auger spectroscopy, in which ordered, two-dimensional arrays of atoms on a crystal surface are sampled and their properties averaged), the SCAT technique, as it is sometimes referred to, can resolve a small portion of a single atom.

The technique is still under development and initially it may be possible to obtain quantitative data on bond lengths, and in combination with other techniques, the element being scanned may be identified. According to recently published discussion, "IBM scientists have published several papers demonstrating the capability of vacuum tunneling to image the topography of metal and semiconductor surfaces with nearly atomic resolution" (*Science*, April 1, 1983).

The IBM observations may have theoretical implications in studying the quantum mechanical tunneling effect, as well as having practical applications in atomic microscopy. The tunneling effect itself occurs in this process because the wave functions of electrons extend into space beyond the surface limits of the solid material. Thus, if two materials are close to each other, but not in contact, the wave functions of electrons from each can overlap, depending on the work functions of the materials and a number of other factors. The probability of tunneling is inversely proportional to the distance of separation between two materials in a vacuum, this distance being on the angstrom scale.

An electron tunneling microscope or imaging system has its crude portions and its ultrasensitive mechanisms. For example, the apparatus employed by IBM consists of a wire scanned along a flat sample surface without being in contact. The wire tip radius is "grossly" formed on the order of only one micrometer, the actual tunneling being between minute whiskers or filaments within the surface. Heinrich Rohrer of the IBM group was quoted in the *Science* piece as saying that the tunneling effect between such sharp filaments is hard to predict, presumably because of the relatively crude construction; "It is still a matter of luck." After the establishment of high-resolution conditions, however, the system is stable for an hour or more.

The precise parts of the SCAT system are involved with the mechanical stability of the apparatus. According to A. L. Robinson, "The 'noise' as it has come to be known moves like an inchworm." That is, the wire tip can be moved in three dimensions. The precise motions are achieved by a piezoelectric, multiple-drive system. As the tip scans over the sample surface two-dimensionally, the tunneling current acts as a guide, with the tip vertically maintaining constant distance from the sample.

The best samples studied by IBM were crystal surfaces of gold and silicon. Silicon's surface, for example, has unit cell dimensions larger and of lower symmetry than the crystal's average. These surface cells can be modified. In a cleaved {111} surface, "the surface atoms rearrange their bonds slightly so that the threefold symmetry is lost . . . [T]he unit cell . . . has the jargon name (2 × 1)." Other treatment of the surfaces of silicon crystals produced larger unit cells (7 × 7, 49 Si atoms).

Among the many possible refinements of scanning tunneling microscopy techniques are those that involve obtaining a determination of electronic wavefunctions of surface atoms. A characteristic of tunneling current is that on the average it varies with $e^{-A\sqrt{\phi}d}$ (where ϕ is the average work function and d is separation between wire probe and sample surfaces). The specific surface electronic wave functions could for the first time be measured on an atom by atom basis and compared with theory.—*PMB*

New Atmospheric Program

The National Science Foundation's Division of Atmospheric Sciences has established an Upper Atmospheric Facilities program within its Centers and Facilities section. The program will support the operation of and the scientific research that uses the longitudinal chain of incoherent scatter radars. The program also will ensure that the chain is maintained as a state-of-the-art research tool available to all interested and qualified scientists.

For additional information, contact Richard A. Behnke, Division of Atmospheric Sciences, National Science Foundation, 1800 G Street, N.W., Washington, DC 20550 (telephone: 202-357-7390).

Science Jobs Tight

In the latest report of the College Placement Council it was noted that a recovery of sorts may be underway for recent graduates in science, engineering, or technology. Based on a survey of 185 placement offices at 160 colleges and universities, the College Placement Survey concluded in its April 1983 report that only one half as many job offers in science, engineering, and technology fields were reported this year, compared with the same time last year. However, although fewer offers were made, more jobs were filled.

Petroleum engineering graduates have commanded the highest beginning salaries of all fields this spring. The average salary offered to petroleum engineers in the class of 1983 is $31,044 per year, almost a 2% increase over last year's starting salary for the same discipline. In second place are chemical engineering graduates who are being offered average starting salaries of $27,336 per year, about 1% higher than last year's figure.

In other technical fields starting salaries ranged down to, and slighly below, $20,000 per year. For example, computer science graduates, by far the largest group in terms of number of offers, had average starting salaries of $23,173. This average was 1.2% above last year's computer sciences' average, which in turn was 9% higher than the 1981 average. By contrast, students majoring in the humanities reported an average salary offer of $14,256 per year.—*PMB*

Atmospheric Instruments

The National Science Foundation's (NSF) Division of Atmospheric Sciences is now accepting proposals requesting only specialized research equipment or instrumentation. The division, within the Directorate for Astronomical, Atmospheric, Earth, and Ocean Sciences (AAEO), aims to echo the theme of increased support for instrumentation of the NSF fiscal 1984 budget request to Congress.

Guidelines for proposals for specialized research equipment and instrumentation are the same as those for research proposals. Each potential major user should describe the research projects for which the equipment will be used. Some institutional contribution is encouraged for the equipment proposals. For additional information on the submission of instrumentation proposals, contact the specific program director in the grant programs section (see list below) or in the new Upper Atmospheric Facilities program in NSF's Centers and Facilities section (see related news item this issue). Guidelines for proposal preparation can be found in NSF publication 81–79, *Grants for Scientific and Engineering Research*.

Specific program directors in the grant programs section are Aeronomy program, Gulamabas Sivjee (telephone: 202-357-7619); Atmospheric Chemistry program, Jarvis L. Moyers (telephone: 202-357-9657); Climate Dynamics program, Thomas Crowley (effective June 1) (telephone: 202-357-0892); Experimental Meteorology and Weather Modification program, Richard A. Dirks (telephone: 202-357-9491); Global Atmospheric Research (GARP) program, Jay S. Fein (telephone: 202-357-9887); Meteorology program, Ronald C. Taylor (telephone: 202-357-7624); Solar Terrestrial program, Dennis S. Peacock (telephone: 202-357-7618); and Upper Atmospheric Facilities program, Richard A. Behnke (telephone: 202-357-7990).

The funding of instrumentation proposals reverses a 10-year division policy to support facilities and instrumentation only as part of research grants; in fact, no special funds have existed for facilities support within the grant programs for several years. The atmospheric sciences division will continue to accept proposals for research instrumentation as part of regular research proposals.

Earliest Mass Extinction

Scientists have uncovered evidence that points to a major mass extinction that wiped out many types of one-celled algae 650 million years ago, near the end of the Precambrian era, according to the National Science Foundation (NSF). Prior to this discovery, the oldest known major extinction had been in the Ordovician Period, some 450 million years ago, when many species of shell-covered marine animals disappeared.

This Precambrian mass extinction was found at several places in the northeast Atlantic region, including Spitsbergen, the Baltic, and eastern Greenland. Andrew H. Knoll, an associate professor of biology at Harvard University, explained, Knoll, whose research was funded by NSF, was working with Gonzalo Vidal, professor of geology at Lund University, when they uncovered their finding.

Knoll and Vidal were studying sequences of algae fossils from the late Precambrian and Cambrian periods deposited in sedimentary rocks from several widely spaced locations in the northeastern Atlantic when they noticed a sharp decline in the number of algal species present. At each site, at a certain level in the rocks, they found that as many as 70% of the known algal species disappeared.

According to Knoll, the mass extinction may have been related to environmental changes that took place during a widespread glacial period occurring at about the same time. "Extinctions are a fact of evolutionary life" and are not randomly distributed through time but are often concentrated in brief periods.

The algae eventually returned, but it took nearly 100 million years, well into the Cambrian period, before the survivors of the extinction diversified into as many species as had existed before, Knoll said.

Books

Georges Bank: Past, Present, and Future of a Marine Environment

G. G. McLeod and J. H. Prescott (Eds.), Westview, Boulder, Colo., xvi + 196 pp., 1982, $27.50.

Reviewed by Tom Sawyer Hopkins

This book is composed of a series of lectures given at the New England Aquarium in early 1980. The intent of these lectures was to summarize the issues of ecology, resource management, and law relating to the Georges Bank. Their underlying theme concerns the controversy of whether or not the bank can support both its present fishery and its oil and gas production. In the sense that interest in oil exploration has since subsided, the book is somewhat outdated. Nevertheless, it presents a very readable overview of one of the world's most productive environments, an environment that provides an excellent example of the economic and ecological problems that can result from misuse of its resources.

The book addresses several controversies. The first is essentially a scientific question: What is the definition of the unique set of oceanographic processes that sustain such a productive marine ecosystem? The basic physical and biological processes are competently summarized by Brad Butman and Gordon Riley, respectively. One is struck by the complete spectrum of dynamics involved in the Georges Bank ecosystem.

On the physical side, the dynamics include nonlinear tidal effects, estuarine circulation in the Gulf of Maine, and Gulf Stream rings on the biological side the spectrum ranges across the favorable vertical scales (coupled to a steady nutrient supply that provides an almost optimal environment for primary production); favorable horizontal scales that contain the primary production for a large suite of pelagic and benthic secondary producers; and the biological interactions of more than 200 species of fish, shellfish, birds, and mammals that capitalize on this extraordinary wealth of production. One is struck also by the disparity between our need for a scientific basis for describing an ecosystem as rich as the Georges Bank and our ability to provide it; marine scientists are still struggling to describe much simpler ecosystems.

Optimal management is the central question concerning the tremendous biological wealth of the Georges Bank. Historically, management was never a concern and even now is far less of one than it should be. It is fascinating to read the early accounts of the Georges Bank fishery (as presented by Daniel Merriman) and to realize, for example, that American history was affected by the 67 huge codfish taken in less than 2 hours by the Mayflower Pilgrims as they hove to off Cape Cod. As a result of this catch, the pilgrims decided not to continue to the Virginia Colony as planned. The New England fisheries thrived on the European salt cod market in the 18th century and then shifted to halibut in the early 19th century. By the late 19th century it was clear that overfishing could be a problem, but the diversity of fish stock and the expanding market were sufficient to keep the fisheries alive and unconcerned. It was not until the arrival of dedicated foreign fleets in the 1960's that the threat of overfishing received political attention.

The Oceanography Report

SITTING DEPOSIT.

The Oceanography Report
The focal point for physical, chemical, geological, and biological oceanographers.

Associate Editor: Arnold L. Gordon, Lamont-Doherty Geological Observatory, Palisades, New York, 10964 (telephone 914/359-2900, ext. 325)

U.S. To Aid Coastal Research

Mary Hope Katsouros

Prior to the 1964 implementation of the 1958 Convention on the Continental Shelf, oceanographers were free to plan and carry out research projects virtually anywhere on or under the seas of the world (see Article 5(1) and 5(8)). Today, dozens of coastal nations regulate marine research within 200 nautical miles (370 km) of their shores, imposing increasingly severe restrictions and creating diverse and uncertain consent procedures. Both the Reagan administration and Congress have acted recently to alleviate some of these jurisdictional problems being experienced by U.S. marine scientists.

On March 10, 1983, President Reagan issued a proclamation on the "Exclusive Economic Zone of the United States of America" and related statements. It is the accompanying "Statement by the President" and the "Fact Sheet" on "United States Oceans Policy" (all three of which are dated March 10), rather than the proclamation, that outline the U.S. position on the conduct of marine scientific research. The "Statement by the President" declares that,

> While international law provides for a right of jurisdiction over marine scientific research within such a zone, the proclamation does not assert this right. I have elected not to do so because of the United States' interest in encouraging marine scientific research and avoiding any unnecessary burdens. The United States will nevertheless recognize the right of other coastal states to exercise jurisdiction over marine scientific research within 200 nautical miles of their coasts, if that jurisdiction is exercised reasonably in a manner consistent with international law.

The "Fact Sheet" states that,

> The President has decided not to assert jurisdiction over marine scientific research in the United States EEZ [Exclusive Economic Zone]. This is consistent with U.S. interest in promoting maximum freedom for such research. The Department of State will take steps to facilitate access by U.S. scientists to foreign EEZ's under reasonable conditions.

On March 11, 1983, Rep. John B. Breaux (D-La.) and Sen. Ted Stevens (R-Alaska) introduced companion bills in Congress (H.R. 2061 and S. 750) to implement the proclamation and statement. Section 105 of the legislation (1) defines a "marine scientific research area," (2) directs the Secretary of State to submit promptly to the appropriate officials of a coastal nation requests by U.S. scientists for permission to conduct marine scientific research in the marine scientific research area of that nation, and (3) instructs the Secretary of State to initiate negotiations for the purpose of obtaining bilateral and multilateral agreements.

Section 105 defines a marine scientific research area as (1) an area the inner boundary of which is the base line from which the territorial sea of the coastal state is measured and the outer boundary of which is a line drawn in such a manner that each point on it is two hundred nautical miles from the inner boundary; and (2) the continental shelf of the coastal state.

In directing the Secretary of State to submit research requests to other countries on behalf of U.S. scientists, Section 105 also directs the Secretary to declare, as part of the request, that the United States recognizes marine scientific research as a freedom of the high seas. However, neither the Policy Statement, the Proclamation, nor the Fact Sheet indicate that such research is a freedom of the high seas.

The international agreements specified in Section 105 are intended to reduce the financial and procedural burden of obtaining research permission. Furthermore, the legislation states that agreements should be sought with those coastal nations in which U.S. marine scientists have expressed the greatest research interest.

Congressional interest in the issue was previously indicated on January 6, 1983, when Rep. Gerry E. Studds (D-Mass.) introduced H.R. 703 to facilitate the conduct of international marine scientific research. This bill differs from the Presidential proclamation and the implementing legislation because it asserts the right of all coastal countries to regulate, authorize, and conduct marine scientific research on the Outer Continental Shelf and in coastal waters out to 200 nautical miles. It provides, further, that marine research may be conducted by scientists in any area under U.S. jurisdiction, provided that the research is conducted in a lawful manner. Like the later legislation, H.R. 703 also requires the Secretary of State to transmit marine research requests from U.S. scientists to other countries and to initiate negotiations that will facilitate international marine scientific research.

What do these developments mean to marine scientists?

Until the issuance of the proclamation, the United States had been unable to process requests by U.S. scientists to conduct research in waters adjacent to other nations unless a portion of the research as to be conducted within 3 nautical miles (5.5 km) of shore, up to 12 nautical miles (22.25 km) for fisheries research, and, with respect to the shelf research, throughout the coastal state's Outer Continental Shelf. This policy caused hardships for many U.S. marine scientists in recent years because they were forced to alter significantly the scope and cost of their research projects in order to gain Department of State cooperation in forwarding research requests. The new role specified for the Department of State in the proclamation will alleviate this problem (memorandum of March 11, 1983, by William Erb, Director, Office of Marine Science and Technology Affairs, Bureau of Oceans and International Environmental and Scientific Affairs, Department of State).

Thus, the science provisions of the proclamation appear to be forthright. They foster marine scientific research by all in the U.S. EEZ, while recognizing the right of other coastal nations to claim jurisdiction over marine scientific research.

It is too soon to predict the reaction of other coastal nations to the Reagan proclamation. Some observers feel that there may be a flurry of unilateral claims by other coastal nations directed solely against the United States—a reaction similar to that which greeted the Truman Proclamation. This opinion is based on the selective nature of the proclamation (for instance, its refusal to recognize coastal nations' jurisdiction over tuna).

There are other issues than the marine scientific community needs to consider especially now when the Congress and the Administration have demonstrated their interest and concern regarding the problems facing U.S. marine scientists who want to do research abroad.

The first set of questions to be addressed deal with the President's statement that the U.S. will recognize other coastal jurisdictions only if they are "exercised reasonably in a manner consistent with international law." How will the standards both of "reasonableness" and "consistency with international law" be established? Should requests be forwarded even if the United States does not agree that all the restrictions imposed by a foreign country are consistent with international law? For example, Trinidad and Tobago specify two additional prerequisites for approval of a research project. The first is that research data and results may be published only with the governments' consent and, second, that all data and specimens are the property of Trinidad and Tobago.

If the U.S. considers a nation's policy unreasonable, should a dialogue be initiated in the hope that a foreign state will alter its policies? In this regard, should the Law of the Sea obligations (Article 248 and 249) dealing with marine scientific research be recognized as the upper limits that U.S. marine scientists will accept, and if so, who should monitor whether the obligations have been met? This last point is extremely important because Article 252 of the Law of the Sea provides that a coastal state may withhold consent to research if the researching state or international organization has unfulfilled obligations.

Article 248 of the Law of the Sea requires that the state or international organization intending to do research within the economic zone or continental shelf of a coastal state provide the coastal state with a full description of the project 6 months in advance. The notification must specify the objective, methods, location, and sponsors of the research project as well as information on the extent to which the coastal state may participate or be represented in the project.

Article 249 comprises two paragraphs enumerating conditions with which the researching state must comply. Paragraph 1 lists the researching state's (or international organization's) obligations, including allowance for coastal state participation or representation, providing preliminary reports and final results, provision for access to or receipt of data and samples, helping (on request) the state to assess results, making these results generally available (subject to paragraph 2), informing coastal states of major changes in the project, and removing any installations or equipment after research is completed.

Paragraph 2 declares that the preceding provisions are without prejudice to other conditions established by the coastal state for the granting or withholding of its consent under Article 246(5), including the requirement of prior agreement for making research results available internationally when a project is of direct significance for the exploration and exploitation of natural resources. Although this provision contemplates possible prior restraint on dissemination or research results, it is limited to research related to natural resources, for which consent is a matter of coastal state discretion. Any other conditions, such as requirement of local publications, are also specifically limited to research covered by Article 246(5).

The second set of issues which need to be examined deal with bilateral and multilateral agreements. The implementing legislation instructs the Secretary of State to initiate negotiations and that agreements should be sought with those coastal states in which U.S. scientists have expressed the greatest interest in conducting marine scientific research.

A recent study of U.S. research-vessel clearance experience in the period 1972–1978 shows that 25% of U.S. research was conducted by two countries—Mexico and Canada [*Wooster*, 1981]. If bilateral agreements are to be pursued, should they be with our neighbors? What are the incentives for a coastal nation to enter negotiations to facilitate marine scientific research? Who will pay the costs associated with bilateral and multilateral agreements? Will scientists be asked to participate in the negotiations?

The questions raised thus far only indicate the need for marine scientists to continue to emphasize the uncertainties they face. The proclamation eliminated the problem which the Department of State had in forwarding research requests to other countries. This is a significant step forward; however, it does not resolve all the political constraints facing oceanographers. To ensure the momentum of the proclamation and the implementing legislation, the community must provide its views to the Administration and Congress on procedural issues and on ways in which marine scientific research and international collaboration can be advanced.

Reference

Wooster, W. S., Research in troubled waters: U.S. research vessel clearance experience 1972–1978, *Ocean. Dev. Int. Law J.*, *9*, 219–230, 1981.

Mary Hope Katsouros is with the Board on Ocean Science and Policy of the National Research Council. This report reflects the personal views of the author and not necessarily those of the National Research Council.

Information Report

NRC Committees on Oceanography

The dust now is settling from last year's restructuring of the National Research Council (NRC) from seven assemblies and commissions to three commissions, two offices, and an independent board (*Eos*, April 27, 1982, p. 250, and March 16, 1982, p. 194). The individual committees and boards within these six new units now are moving full-speed ahead. This information report reviews four of the new boards that touch on oceanography.

Of the all the shifts made to create these four boards, the biggest overhaul involved merging the old Ocean Sciences Board with the old Ocean Policy Committee to form a new Board on Ocean Science and Policy (BOSP) (*Eos*, May 3, 1983, p. 172).

BOSP, which is within NRC's Commission on Physical Sciences, Mathematics, and Resources, first met on May 4, with former NSF director John B. Slaughter, now chancellor of the University of Maryland, at the helm. One of the main problems facing the board, according to Mary Hope Katsouros, BOSP executive secretary, is the vast array of new satellite technologies available and the current lack of a consensus on which ones will be most useful to oceanographers. In addition, oceanographers will need to address the implications of the U.S. not being party to Law of Sea for marine scientists. A declining budget, fragmentation of activities among government agencies, and the need for one spokesman for the oceanographic community also face these scientists.

The marriage of the old Climate Board and the Committee on Atmospheric Sciences produced the Board on Atmospheric Sciences and Climate (BASC), within the same commission as BOSP. The link between oceanographers and atmospheric scientists and climatologists has become increasingly strong during the last decade, so much so that oceanographers constitute a sizeable contingent on BASC and its various committees. To address the most important scientific issues in atmospheric science and climate, scientists need to look broadly at global problems. These problems, according to Fred D. White, BASC staff officer, include the Southern Oscillation's possible connection to climate; solar-terrestrial relations and their affect on the atmosphere; atmospheric chemistry, including acid rain and global tropospheric chemistry; and mesoscale phenomena.

The Polar Research Board (PRB), within the same commission as BOSP and BASC, touches directly on oceanography. The main problems facing polar scientists that the board will address, according to W. Timothy Hushen, PRB executive secretary, include the lack of ice-strengthened vessels; the great distance between home ports and the southern oceans; and the high price of ice breakers needed to get to research sites.

Within NRC's Commission on Engineering and Technical Systems, the Marine Board (MB) is the result of a merger last year of the Maritime Transportation Research Board and the old Marine Board. Although not working on ocean sciences per se, the Marine Board's work relates to the engineering and technological aspects of ocean science. The board also reviews issues concerning ocean and coastal engineering, maritime commerce, ship building, and safety, according to Aurora M. Gallagher, MB staff officer.

Other NRC boards and committees also touch on oceanography or oceanographic-related topics; one such group is the Geophysics Study Committee, which released a report in December on paleoclimate and paleoceanography and just released a report on estuarine research and the need for an interdisciplinary approach. From time to time, *Eos* will review the activities of these other boards.

The NRC was established by the National Academy of Sciences (NAS) in 1916 to associate the science and technology communities with the academy's purposes of furthering knowledge and of advising the federal government. The NRC is the principal operating agency of NAS and the National Academy of Engineering; it is administered by both academies and the Institute of Medicine.

For each of the four boards discussed in detail in this report, the NRC staff contact, the board chairman, the highlights of projects completed within the last two years, current projects, and contemplated projects are listed below. A summary of board objectives and goals, which are often called "terms of reference," is also provided for each group. Additional information may be obtained from the boards at the following address: 2101 Constitution Avenue, N.W., Washington, DC 20418.

Board on Ocean Science and Policy (BOSP)

NRC Staff Contact: Mary Hope Katsouros and Nancy Maynard (effective July 1), Executive Secretaries (telephone: 202-334-2714)

Board Chairman: John B. Slaughter, Chancellor, University of Maryland, Main Administration Building, Room 1101, College Park, MD 20742

Objectives and Goals: "To contribute to the advancement of the scientific understanding of the ocean by the maintenance of a continuing oversight of the health of the ocean sciences and the stimulation of their progress. To foster the application of scientific knowledge to the wise use of the ocean and its resources. To assist in the formulation of national and international marine policy and to clarify scientific issues that affect ocean policy. To consider questions of international ocean science and, in particular, the implications of the Law of the Sea Treaty on marine science and scientists. To facilitate communication among ocean scientists and between ocean scientists and scientists in related fields. To address marine science issues involved in efforts to coordinate international oceanographic research, improve technical assistance and cooperation, and assist in the development of coherent fisheries policies."

Completed Reports:

Department of Energy Oceanographic Program Review

Stable Reference Areas for Evaluation of Deep Seabed Mining

Petroleum in the Marine Environment

Ocean Research for Understanding Climate Variation—Priorities and Goals for the 1980's

Two Special Issues in Satellite Oceanography: Ocean Dynamics and Biological Oceanography

U.S. Directory of Marine Scientists 1982

An Assessment of Computational Resources Required for Ocean Circulation Modelling

Academic Research Vessels 1985–1990

United States Interests and Needs in the Coordination of International Oceanographic Research

Interim Report on Stable Reference Areas

An Evaluation of Fishery and Aquaculture Programs of the Agency for International Development

Marine Technical Assistance to Developing Countries: The U.S. Role

Current Projects:

Future of Marine Geology and Geophysics Review

Long-Term, Large-Scale Ocean Science

Study on Ocean Thermal Energy Conversion

Study on Land, Sea, and Air Disposal of Industrial and Domestic Wastes

Workshop on Global Observations and Understanding of the General Circulation of the Oceans

Study on Mechanisms to Facilitate U.S. Marine Scientific Research in Waters of Foreign Coastal States

Effects of Human Activity on the Coastal Ocean

Projects Contemplated:

Large Fluxes of Organic Matter in Oceans

Ocean Climate Research Panel

Study on Methods for Defining the Outer Boundaries of the U.S. Continental Shelf and their Policy Implications

Board on Atmospheric Sciences and Climate (BASC)

NRC Staff Contact: John S. Perry, Executive Secretary (telephone: 202-334-3517)

Board Chairman: Thomas F. Malone, Holcomb Research Institute, Butler University, Indianapolis, IN 46208

Objectives and Goals: "To advance our understanding of the atmosphere and climate, and to improve our ability to apply this knowledge for our benefit." Among the board's special functions are providing advice and guidance to appropriate government agencies on objectives, priorities, plans, and implementation strategies for the National Climate Program, on U.S. participation in international research, and for focused national programs in "critical areas of atmospheric science and climate research"; fostering the application of scientific knowledge of the atmosphere, climate, and social/economic systems to make wise use of the atmosphere and climatic resources for the benefit of our country and other nations; studying the impact of weather and climate on human society and how humans affect the atmosphere and climate; and facilitating "communication among the diverse community of scientists concerned with the study of the atmosphere and the climate system, and of their interactions with society."

Completed Reports:

Carbon Dioxide and Climate: A Second Assessment

Solar Terrestrial Research for the 1980's

Current Mesoscale Meteorological Research in the United States

Current Projects:

Report of the Carbon Dioxide Assessment Committee

Global Tropospheric Chemistry: Future Program Needs

El Niño

Solar-Terrestrial Research

Global Atmospheric Research Program (GARP) and Associated First GARP Global Experiment (FGGE), Monsoon Experiment (MONEX), and Alpine Experiment (ALPEX)

Low-Level Wind Variability

Projects Contemplated:

BASC will probably become involved in the Stormscale Operational and Research Meteorology (STORM) program (*Eos*, March 22, 1983, p. 113)

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Cover. What may appear at first to be a fish-food dispenser is in fact the lower part of a current meter suspended 1 m above the continental shelf offshore of Cedar Key, Florida. The picture was taken by scuba diver Jeffrey H. Parker just prior to the release of the bottom-attached mooring. Fish are apparently attracted to the mooring and take advantage of slack tidal currents to explore the rotor (bottom) and vane (middle). Results from this and other current-meter moorings deployed during the 1981–1982 winter may be found in G. O. Marmorino, Variability of Current, Temperature, and Bottom Pressure Across the West Florida Continental Shelf, Winter 1981–1982, *J. Geophys. Res.*, *88*, in press. (Photo courtesy of G. O. Marmorino.)

Marine Board (MB)

NRC Staff Contact: Jack Boller, Executive Director (telephone: 202-334-3119)

Board Chairman: John E. Flipse, Texas A&M University, College Station, TX 77843

Objectives and Goals: "The Marine Board serves the national interest by initiating, and by responding to requests for evaluations and giving advice on the nation's capability to accomplish its marine and maritime objectives. In its advisory role, the Marine Board considers questions of the relation of engineering and technology to coastal and offshore resource development and operations; to navigation and the commerce of the sea and waterways; to related human resources and onshore activities; and to the establishment and implementation of public policies. The board identifies opportunities and needs for engineering studies and new technologies and recommends appropriate actions."

Completed Reports:

Technologies for Measurement While Drilling

Measuring Ocean Waves: Ocean Instrumentation to Serve Science and Engineering

Understanding the Arctic Sea Floor for Engineering Purposes

Current Projects:

Fates and Effects of Drilling Fluids and Drill Cuttings in the Marine Environment

National Capabilities for Arctic Ocean Engineering

Alternatives for Outer Continental Shelf Safety Information and Analysis Systems

National Marine Issues and Opportunities

Engineering Support of Deep Ocean Drilling for Science

Ship Collisions with Bridges

Projects Contemplated:

Engineering Implications of Mean Sea Level Changes

Support of Ocean Science and Engineering Research

National and International Cooperation and Information Exchange

This information report was contributed by Barbara T. Richman, Eos News Writer.

News & Announcements

First Subsea Seismic Station

The first self-contained seismic station was installed recently in the ocean floor at a depth of 5.5 km, about 1,600 km southwest of Tahiti, close to the Tonga Trench. The region is thought to be the earth's most active seismic zone. The station will help scientists to determine if the subseafloor is a suitable place for recording seismic events by comparing noise levels with those of land-based stations and to determine whether marine seismic stations are possible to maintain. Eventually, marine stations could be used to help scientists predict earthquakes.

The computer-controlled seismic station, installed by the Naval Ocean Research and Development Activity's (NORDA) Marine Seismic System (MSS) Program Office, consists of four seismometers plus assorted sensors packaged in an 11 m long x 0.2 m diameter cylinder designed to resist corrosion and to withstand more than 700 kg/cm² of pressure. The cylinder was placed by the *Glomar Challenger* during Leg 91 of the Deep Sea Drilling Project (DSDP) in a 122-m deep borehole drilled into the ocean crust. A recoverable 4,500 kg data processing package, resting on the ocean floor nearby, powers the station. The package, containing tape recorders, data processing equipment, and batteries, can record seismic signals for 45 days.

L. A. Ballard, manager of the Marine Seismic System program, said that the data produced by the subseafloor station is comparable to that produced by such landbased stations as Yellowknife, Northwest Territories, Canada, and the seismic station in La Jitas, Texas. The La Jitas station is considered by scientists to be the quietest one in the country. The MSS program is sponsored by the Defense Advanced Research Projects Agency (DARPA) of the Department of Defense.

SURF Request

The Southeastern Undersea Research Facility (SURF) of the University of North Carolina at Wilmington (UNCW) has issued a request for proposals to conduct research on the continental shelf of the Atlantic Ocean and the Gulf of Mexico during calendar year 1984. The research would be part of the National Oceanic and Atmospheric Administration (NOAA) National Undersea Program.

SURF is one of four national undersea programs established by NOAA's Office of Undersea Research to improve the understanding and management of marine resources. The program is operated by UNCW under a cooperative agreement with NOAA and is sponsored by the Southeastern Consortium for Undersea Research Efforts (SECURE), an association of academic and research institutions and government agencies from Virginia, North Carolina, South Carolina, and Georgia.

Proposals will be evaluated by the SECURE National Peer Review Committee. Investigators should address contemporary management problems in areas of research that include seafloor properties and processes: geological, geophysical, and geothermal aspects of the seafloor, including sediment transport, stability, fluxes, mineral resources, and gradients in the water column; ocean technologies and services; fisheries; and pollution.

Deadline for submission of proposals is September 30, 1983. For additional information contact NOAA (RD/SP2), 6010 Executive Blvd., Rockville, MD 20853 (telephone: 301-443-8391) or Southeastern Undersea Research Facility, University of North Carolina at Wilmington, P.O. Box 3725, Wilmington, NC 28406 (telephone: 919-343-4402 or 919-762-7615).

Meetings

Flow Cytometry and Sorting

For the first time oceanographers have a tool, known as a flow cytometer and sorter, which is useful for simultaneous measurement of multiple parameters of individual cells and particles at rapid rates. We are now able to exploit the fluorescent capability of pigments and stains as signals to quantify and separate subpopulations of cells and particles in the 1.0 to 150 μm size range. Analysis rates exceed 1000 cells per second and high sensitivity is attained using laser excitation.

The addition of this new technology to the ocean sciences will enable researchers to address problems which were previously intractable. The first unit, funded by the Office of Naval Research and the National Science Foundation, will be at Bigelow Laboratory for Ocean Sciences in West Boothbay Harbor, Maine, in the laboratory of Clarice M. Yentsch and David A. Phinney. In anticipation of this award, a workshop course on flow cytometry (FCM) and sorting techniques was held from October 24 through November 1, 1982, at the Bermuda Biological Station.

The workshop explored oceanographic applications of a Coulter Instruments Model EPICS V with one Coherent 5-Watt argon-ion laser. The participants brought samples of cell cultures and natural populations to test the feasibility and limitations of FCM to specific projects. Results from the first trials at Bermuda were promising, and we wish to bring the potential of this class of instruments to the attention of the oceanographers and limnologists. A follow-up workshop is being planned at the Bigelow Laboratory for Ocean Sciences for October 4–10, 1983.

Most oceanic productivity is directly linked to the first step in the food web, the phytoplankton—microscopic plants which convert solar energy into chemical energy of sugars and other compounds. Collectively, phytoplankton are the pastures of the sea. Phytoplankton as well as bacteria and small animals exist essentially as single cells and small entities in the fluid medium. Most of these forms are within the size limits of the flow cytometer, permitting physiological and ecological studies.

Phytoplankton have their own innate fluorescing materials such as chlorophylls and biliproteins, which are pigments used in photosynthesis. It is due to this autofluorescence that researchers recently discovered an abundance of very small (~1 μm), bacteria-like forms which contain pigments. These organisms, belonging to the cyanobacteria (or blue-green algae), are now found to be ubiquitous in the upper layers of the world's ocean. Although to date we know very little about what were previously thought to be "exotic" forms, in an evolutionary sense they are extremely interesting. Cyanobacteria probably were the first plant forms to colonize the oceans, and research has demonstrated that many have pigments which protect them from harmful ultraviolet radiation. By photosynthetically producing oxygen, these organisms are a fundamental support for life as we know it today.

Most methods currently used to quantify minute life forms either have been very tedious and statistically unreliable, such as microscopy, or have relied on bulk measurements, thus masking variance and rare events. Researchers have had great difficulty in distinguishing between living (organic) and nonliving (inorganic) forms. Indeed, inorganic sediments occupy the same size range as do the bacteria and phytoplankton. Now it is possible to use chlorophyll fluorescence to distinguish phytoplankton, protein stains to detect bacteria and small animals, and DNA stains to estimate growth rates. Light scattering can be a useful index for inorganic sediment particles using flow cytometry.

This meeting report was prepared by Clarice M. Yentsch of the Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, ME 04575.

Books *(cont. from p.401)*

Robert Edwards discusses the Georges Bank fisheries during the 1962–1977 period, when foreign fishing peaked and then declined as a result of dwindling stocks and tardy restrictions. The total catch remained fairly high at 700,000 tonnes until 1975, but only because of shifts in stock: The silver hake, haddock, and cod catches peaked early in 1965, the herring in 1968, and the mackerel in 1973. Had some restraint been observed, these stocks might have remained above their minimum spawning size and consequently greatly increased the integrated yield. No restraint was observed, of course, and the stocks were harvested faster than natural spawning could replace them.

However, the activation of the slow feedback loop through the political system began no later than the establishment of the International Convention for the Northwest Atlantic Fisheries (ICNAF). Henry Lyman continues this discussion by summarizing the role of the New England Regional Fishery Management Council on Georges Bank, which was established under the Fishery Conservation and Management Act (FCMA) of 1976. The FCMA has very explicit objectives: to restore overfished stocks, to maintain fisheries resources, to promote unused species, and to allow foreigners to harvest surplus stocks. The council had difficulty gaining sufficient authority and winning popular support among fishermen. In the several years since its implementation, the council can point to a number of successes, most of them linked to the restrictions placed on foreign fleets.

The FCMA is not autonomous, and its interests are often compromised for U.S. foreign policy considerations. For example, Soviet fishing infractions were waived in deference to the SALT negotiations, and the Canadian dialogue over fishing rights was influenced by the Canadian assistance to the U.S. hostages in Iran. Francis Cameron summarizes these problems and the role of international law in providing a workable treaty with the Canadians over the Georges Bank fishery. The problem is twofold: territorial rights and fisheries management. The latter need not wait for the former. Currently, stocks are managed through uncoordinated programs. The objectives and structure of such a treaty are far less an obstacle than is agreement on the catch entitlements for the two nations.

The fisheries community sees a threat in the use of the Georges Bank for oil and gas drilling: Drilling disrupts and endangers fishing, and drill wastes and oil spills pollute the grounds. Whether the drilling is tolerable is another question. Sarah Bates presents some of the legal aspects of the oil leasing and concludes that, "Courts simply are not and cannot be the forum in which to debate the wisdom of OCS [Outer Continental Shelf] activity on Georges Bank."

Much of the dichotomy lies in the appraisal of the relative value between nonrenewable and renewable resources. In the one pro-oil lecture, J. R. Jackson, Jr., contends that the possibility of retrieving 21 days' supply of fuel for the U.S. justifies the OCS activity, and, as reassurance against an environmental accident, he cites the industry's safety record. An assessment of the impacts of oil pollution is elusive since, as Carl Sindermann points out, crude oil contamination of resource species does not appear to cause a definite hazard to human consumers. However, serious, long-term effects on the marine ecosystem are possible but beyond our ability to quantify. The more complicated life forms may be sensitive to environmental stress at one stage but not at another, or their behavior may be altered significantly. Karen Pryor reviews the susceptibility of the Georges Bank mammals and birds to oil pollution. Again, because of complicated behavior patterns, the effect on a community can be more dramatic than that on an individual.

While the threat of oil drilling on Georges Bank has abated, the argument is still very timely. If the human feedback loop is ever to be effective, we must educate ourselves in ecological principles and take remedial action before problems arise, not afterward.

The introductory and final lectures are very appropriate to this theme. Guy McLeod and John Prescott introduce the series through a summary of the Georges Bank's fishery resource and the seemingly inevitable disregard for it by the federal and private oil interests. Warren Johnson closes the series with an eloquent plea for sanity in our use of our technology and the appetites that it generates.

Tom Sawyer Hopkins is with the Brookhaven National Laboratory, Upton, NY 11973.

Igneous and Metamorphic Petrology

M. G. Best, W. H. Freeman, San Francisco, xviii + 630 pp., 1982.

Reviewed by James D. Hoover

So many new and exciting topics in petrology have appeared over the last several years that it has become difficult to find a text that deals adequately with fundamentals as well as current topics the present book may be one of the better texts in its field today because it achieves this combination with clarity and appropriate emphasis. The book provides a comprehensive coverage of descriptive, theoretical, and experimental topics. The relationship between the origin and evolution of igneous and metamorphic rocks and the associated physical and tectonic processes is the unifying theme of the text.

The book is intended as a text for undergraduate geology majors with a background in physical and historical geology and mineralogy. It is divided into four main categories: magmatic rock bodies, magmatic systems, metamorphic bodies and systems, and the early history of the earth and other planetary bodies. The organization of the first three of these sections is intended to be flexible in scope, emphasis, and variety of subject matter. Each chapter is outlined, prefaced with an overview of the section, and summarized in outline form. Key terms appear in bold type, and study questions are provided in interpretive chapters. Breadth and clarity of subject matter is emphasized, and good use is made of figures, tables, and photographs of rocks in the field, in hand specimen, and in thin section. The appendix contains a summary of some petrographic techniques, a review of the physical and optical properties of some rock-forming minerals, and representative chemical analyses of some major rock types.

The introductory chapter includes discussion on methods of investigation, philosophy of classification, and the flow of energy in geologic systems from a thermodynamic point of view. Both the igneous and metamorphic parts of the book follow a common format: first an overview of basic principles, then descriptive and interpretive material combined with discussions on processes and theoretical applications.

The section on igneous rocks begins with an overview on philosophy of classification and the use of the fabric, compositional data, variation diagrams, trace element data, and isotopic data. The section emphasizes the interrelation between tectonism, magmatism, and metamorphism within the framework of plate tectonics. The descriptive part of the igneous section is organized into chapters on calc-alkaline volcanic rocks, calc-alkaline plutonic rocks, subalkaline basaltic and ultramafic rocks, and alkaline rocks. Each of these chapters contains excellent descriptions of field relationships, mineralogy, and fabric discussed also in terms of the physical and chemical properties of magmas. The sections on calc-alkaline rocks includes discussions on volcanic features and eruptive sequences and the origin of granitic magmas. Layered intrusions, mid-ocean ridge basalts, and ophiolites are among the topics discussed in the section on subalkaline basaltic rocks. Tholeiitic-alkaline transitions and the characteristics of strongly alkaline rocks, kimberlites, and carbonatites are among the topics discussed in the section on alkaline rocks, together with an overview of concepts bearing on their origin.

The second part of the igneous section contains a survey of phase equilibria, the compositional and kinetic aspects of magmas, petrogenetic processes for the generation, diversification, and ascent of magmas, and the role of tectonic forces in controlling them. Included in this section are discussions on silicate melt structures, diffusion, nucleation and crystallization in silicate systems, and an overview of concepts such as thermogravitational diffusion, double diffusion processes, and the physical aspects of magma emplacement.

The five chapters on metamorphic rocks bodies deal with fabrics, compositions, field relations, and the associated physical and chemical processes of metamorphic rocks. The introductory section is outstanding in its summary of fundamentals such as classification criteria, recrystallization processes, and the concepts of metamorphic grade, zones, and facies. The importance of the mineralogic, chronologic, and geometric aspects of fabric in metamorphic rocks is clearly presented. The author enhances the section with discussion on the origin of metamorphic fabric in light of solid state crystal growth, response to stress, and plastic flow. Topics such as anisotropic fabric, the role of fluids, and experimental investigations of deformational behavior are also treated in this section. The geometric methods of illustrating correspondence between bulk and mineralogical composition as a function of P, T, or metamorphic grade are presented in terms of the phase rule. Examples of metamorphic reactions, thermodynamic principles, kinetics, analysis of mineral assemblages (isograds), and metamorphic differentiation are also presented in the process-related sections.

The last two chapters in the book deal with the early history of the earth and other planetary bodies. Among the topics covered are Archean and Proterozoic terrains, the chemical evolution of the mantle, crust-mantle differentiation, and core segregation. The section on extraterrestrial petrology encompasses overviews of lunar petrology, comparative planetology, meteorite studies, and accretion of the earth and other planetary bodies.

Overall, the book is a remarkable compendium of classical and current concepts in which the importance of intelligent gathering and evaluation of facts is stressed. The most positive aspects of the text are the scope and generally thorough level of treatment of subject matter, and style of presentation. Various types of petrologic data are presented to the reader, and the salient features summarized. Relevant problems are also pointed out, and alternate explanations or models are proposed. Moreover, the author lucidly blends current research and ideas into the discussions.

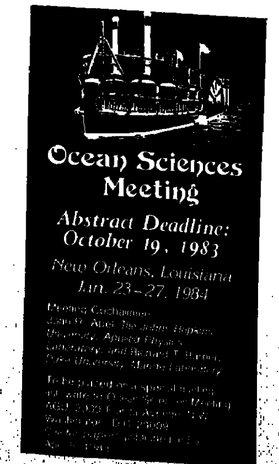
The book has drawbacks, however, in certain aspects of its organization and in its treatment of certain topics. Topics on petrogenesis are interspersed in descriptive sections to stimulate interest but often seem out of place without the aid of concepts explained in later chapters. Some topics, such as exsolution and evolution of the mantle seem misplaced, and the treatment of other topics, such as trace element and isotopic applications, seem incomplete. For example, the behavior of useful trace elements (e.g., the REE's) and the evaluation of such data is not well illustrated, nor is there reference to lead or hydrogen isotopic studies. It is also notable that discussion of the Hawaiian volcanic sequence warrants only one paragraph in a chapter on alkaline rocks. Little mention is made of geothermometry or geobarometry in either the igneous or the metamorphic sections. Few quantitative examples of thermodynamic applications are presented up to the last chapter on metamorphism. Recent work on topics such as the paragenetic relations of metapelites is also missing. These drawbacks, however, are minor in the context of the entire presentation. As an introductory text, the book is very good. Because of its scope, the book may also be useful as a general reference to the many topics in hard rock petrology.

James D. Hoover is with the Department of Geological Sciences, University of Texas at El Paso, El Paso, Texas 79968.

New Publications

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Atlas of Tropical Pacific Wind-Stress Climatology, J. J. O'Brien and S. R. Goldenberg, Florida State University, Tallahassee, 182 pp., 1983, $20.



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Replies to ads with box numbers should be addressed to Box ___, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D. C. 20009.

For further information, call toll free 800-424-2488 or, in the Washington, D. C., area, 462-6903.

POSITIONS AVAILABLE

Research Scientist II/University of New Hampshire. The solar-terrestrial theory group at the University of New Hampshire seeks applications for a Research Scientist II to undertake a variety of theoretical problems on plasma and MHD processes in the solar atmosphere and the solar wind, and related energetic particle phenomena.

Minimum qualifications: Applicant must possess a Ph.D. or equivalent professional degree, with research background to doctorate, with training in theoretical space plasma physics or a related field (e.g. theoretical plasma fusion research), or masters degree and at least three years of research experience which is closely related to project work. Salary range $20,110 to $31,260; normally starting salary not to exceed $29,510.

Resume and three letters of reference should be sent before August 15, 1983, to: Dr. J.V. Hollweg, Department of Physics, University of New Hampshire, Durham, New Hampshire 03824.

The University is an affirmative action/equal opportunity employer.

Opportunities for Graduate Studies in the Atmospheric Sciences at the Georgia Institute of Technology. Openings are available for outstanding individuals seeking an M.S. or Ph.D. degree in graduate studies in the atmospheric sciences. For successful applicants, these positions include 1/2 time research assistantships with starting salaries ranging from $7,000 to $12,000/12 months, depending on the degree being sought and the student's qualifications. All tuition and fees are also covered by the institute.

The Atmospheric Sciences Program at Georgia Tech is part of the School of Geophysical Sciences and is uniquely structured academically in that major emphasis is given to three areas of atmospheric sciences, namely, Dynamic Meteorology, Physical Meteorology, and Atmospheric Chemistry. Major research efforts in which students are currently involved include studies in wind and solar power, climate modification, air pollution, uses of satellite meteorology, measurements of aerosols in the atmosphere, modeling of planetary circulations, mesoscale and boundary layer dynamics, development of laser instrumentation for the detection of atmospheric aerosols and gases, global airborne measurements of atmospheric trace gases, photochemical and gas kinetic studies of atmospheric transformations, studies of biogeochemical cycles, and one-, two- and three-dimensional chemical and dynamic modeling of the troposphere and stratosphere.

Students interested in being involved in these or other exciting Atmospheric Sciences projects at Georgia Tech should write for information to:

Dr. Douglas D. Davis
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta, GA 30332

Howard University/Graduate Faculty Position. The Department of Geology/Geography invites applications for a tenure-track position in geochemistry at rank of assistant or associate professor beginning August 1983. Position involves development of graduate research program at Master's level. Desired specialization includes environmental geochemistry, geochronology, isotope geology. Send letter of application, resume and names of three references to Dr. David Schwartzman, Department of Geology/Geography, Howard University, D.C. 20059.

Postdoctoral Associate The Johns Hopkins University Instrumentation for Ultraviolet Astronomy. Applications are invited for the position of Postdoctoral Associate in the Department of Physics. The research areas include design of mirrors for extreme ultraviolet spectroscopic instrumentation and detector systems for astronomy. Additional research opportunities exist using satellite, space shuttle, and rocket borne astronomical experiments.

A background in astrophysics is desirable, however, candidates with strong experimental skills but who have backgrounds in other scientific areas are encouraged to apply.

Send a resume with three references to Warren Moos, Physics Department, Johns Hopkins University, Baltimore, MD 21218

Argonne National Laboratory/Chemistry Division. An immediate position for a postdoctoral is available for atmospheric chemistry studies based on mass spectrometric analysis of the stable isotopic composition of atmospheric trace gases. Problems include source budgets and temporal variations of atmospheric trace gases and determination of atmospheric OH free radical concentrations using stable isotope tracers. Experimental techniques involve preparation of gas samples derived from trace gases using carrier gas from systems with cryogenic and chemical separation methods and precision mass spectrometric analysis. Send resume to: Mr. Walter McFall, Personnel Division, Bldg. 201/TAM 80, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439

An equal opportunity employer

Temporary Faculty Position/UCLA. The Department of Earth and Space Sciences, UCLA, seeks applications for a temporary faculty position in the area of sedimentology, basin analysis, stratigraphy, and regional geology.

A Ph.D. or equivalent is required. There is no restriction as to the level. Duties will include undergraduate and graduate teaching, supervision of theses and dissertations, and development of a research program in the area of specialization. Field-based experience will be taken into consideration. The appointment will begin July 1, 1983, will be full-time nine-month, and will be renewable annually. The Department hopes to convert this position in 1984 or later, but has no assurance there will. Send resume to:

Chairman
Department of Earth and Space Sciences
University of California
405 Hilgard Avenue
Los Angeles, CA 90024

UCLA is an affirmative action equal opportunity employer.

Chairman—Department of Geological Sciences, Wright State University. The Department of Geological Sciences, invites applications for the position of chairman, to be appointed September 1983. We seek a dynamic individual with administrative talent and an appreciation for research and practice in field educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with 12 faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic research.

Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
Dayton, OH 45435

Wright State University is an affirmative action/equal opportunities employer. Closing date for the position is October 31, 1983

Research Faculty Position in Space Physics/Boston University. The Astronomy Department at Boston University expects to have a research faculty position available for the 1983/84 academic year.

Applicants are sought who have a proven research record as evidenced by publications and recommendations and who have an interest in teaching at the graduate and undergraduate level. Applicants with research programs in any area of space physics will be considered, however, preference will be given to those with interests in ionospheric or magnetospheric space plasma physics. Rank will depend on qualifications and experience.

Applicants are particularly sought who can bring partial salary support. Teaching duties are based on the proportion of salary supported by departmental funds.

Please send a curriculum vitae, names of three persons who can provide an evaluation of your teaching and research and a brief statement of current research interests to:

Kenneth James, Chairman
Astronomy Department
Boston University
725 Commonwealth Avenue
Boston, MA 02215
(617)353-2627

Boston University is an equal opportunity/affirmative action employer.

Scientists/Physicists/Engineers/ Science Systems and Applications, Inc. (SSAI). Science System and Applications, Inc. has ongoing projects with personnels with BS/MS/PhD degrees in various fields of physics to carry out numerical analysis, modeling, remote sensing and analysis satellite observed geophysical parameters. We are looking for people with atmospheric sciences/meteorology/solar sciences background, strong background in working with FORTRAN language and large scale computer is required. Please send your resume with references to:

Science Systems and Applications, Inc., 10210 Greenbelt Road, Suite 640, Seabrook, MD 20706.

University of Colorado, Boulder, Geochemist Position. Geochemist with active research program, stable isotopes, radioactive isotopes, and/or trace elements is being sought for a joint appointment in the Department of Geological Sciences and the Geosciences (CIRES) of the University of Colorado.

The one-half time position within the Department of Geological Sciences is tenure track at the assistant or associate professor level with a starting salary of $12,000—$15,000 for the academic year.

Teaching load will be half that of full-time faculty. The position within CIRES will be as a fellow with appropriate office and laboratory space. One-half academic year salary will be guaranteed by CIRES for two years at the departmental rate, after which incumbent must generate his/her CIRES salary from external sources. Incumbent may augment salary further by generating three months of summer salary from contracts and grants, and consulting.

Applicants with experience, publications, and/or new ideas using research equipment preferred. Preferred starting date would be January 1, 1984. Closing date for applications is October 1, 1983.

Applications should include statement of research and teaching interests, experience, a full vitae, and four letters of reference.

Apply to: Professor Charles Stern, Chairman, Geochemist Search Committee, Department of Geological Sciences, Campus Box 250, University of Colorado, Boulder, CO 80309.

The University of Colorado is an equal opportunity/affirmative action, Section 504 employer

Research Scientist/Space Plasma Physics, University of Iowa. A research position is available in the Department of Physics and Astronomy, The University of Iowa, for theoretical and interpretative studies of wave-wave plasma interactions and in the solar wind. These investigations are to support the interpretation of data being obtained from spacecraft projects such as Dynamics Explorer, International Sun Earth Explorer and Voyager. The applicant must have a Ph.D. with good qualifications in plasma physics theory and should have some experience in the interpretation of space plasma physics data.

Send a resume and the names of three references familiar with the applicant's work to: D.A. Gurnett, Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, telephone 319-353-3527.

The University of Iowa is an affirmative action/equal opportunity employer.

Director/ Geophysical Fluid Dynamics Laboratory: The Environmental Research Laboratories, NOAA. The U.S. Department of Commerce in Princeton, New Jersey, is seeking applicants for a scientific manager to serve as Director, Geophysical Fluid Dynamics Laboratory. The Director plans, develops, implements, and evaluates research programs to expand the scientific understanding of those physical processes which govern the behavior of the atmosphere and the oceans as complex fluid systems. This involves extensive inter- and intra-agency coordination as well as the direction of a 100-member staff engaged in research activities. Position is Career Reserved in the Senior Executive Service. Salary range: $56,915 to $67,200 per annum—negotiable based on experience, scientific achievement, and technical/managerial qualifications.

QUALIFICATIONS: Knowledge of theory and state of the art in a combination of disciplines (meteorology, oceanography, hydrology, classical physics, fluid dynamics, chemistry, and applied mathematics) to design, direct, and evaluate interdisciplinary research programs. Competence in the scientific management of theoretical and experimental research studies of a large-scale nature. Personal research in meteorology or oceanography. Executive competence in broad areas of administration such as program planning and evaluation, multigroup coordination, resource acquisition and administration, organizational representation, and human resource utilization including EEO.

TO APPLY: Interested persons should contact Ms. Barbara J. Peterson, NOAA/ERL, Personnel Services Division (RF502), 325 Broadway, Boulder, CO 80303 (303) 497-3780 or FTS 320-3780 for application forms. Reference Vacancy #NOAA/ERL 82-269. Position announcement closes July 8, 1983.

AN EQUAL OPPORTUNITY EMPLOYER.

Florida International University/Faculty Positions in Geology. The Earth Sciences program at Florida International University is expanding and plans to increase the number of its faculty positions in the next few years. In order to complement existing instructional and research strengths, the university invites applications for tenure track positions at the assistant professor level in the following areas of specialization.

1. Stratigraphy/Sedimentology
2. Geophysics/Marine Geology
3. Igneous Petrology/Geochemistry/Economic Geology

Successful applicants must have demonstrated an ability to conduct high-quality teaching and the potential to establish a productive research program in their area of specialty.

Subject to final approval of funding, appointments will begin in August 1983 (deadline for application July 30, 1983) and/or January 1984 (deadline for application November 15, 1983).

Send a resume, brief description of teaching and research interests, transcripts and three letters of recommendation to:

Dr. L. Keller
Department of Physical Sciences
Florida International University
Tamiami Trail, Miami, Florida 33199

Florida International University is a member of the Florida State University system and an affirmative action/equal opportunity employer.

Department of Scientific & Industrial Research/ Research Scientist in Geomagnetism, Physics & Engineering Laboratory, Christchurch, New Zealand. The Research Section of the Physics and Engineering Laboratory, Geophysical Observatory in Christchurch has a vacancy for an atmospheric physicist to join a research group, currently working on projects related to the international Middle Atmosphere programme. An extensive database of geomagnetic and ionospheric records is available.

Qualifications: Post Doctorate research experience in an appropriate field.

Salary up to NZ$35,393 per annum depending on qualifications and experience.

Further information, application forms etc., may be obtained from The Ambassador, New Zealand Embassy, Washington, D.C. Applications should quote vacancy number 1780 and forward applications accompanied by a resume to:

The Ambassador
New Zealand Embassy
37 Observatory Circle NW
Washington, D.C. 20008.

APPLICATIONS MUST ARRIVE BY JULY 11, 1983.

Faculty Position for HREM Specialist/Arizona State University. A tenure-track faculty position at the Associate or Assistant Professor level is available at Arizona State University for a high-resolution electron microscopy specialist to work with the ASU Facility for High Resolution Electron Microscopy within the Center for Solid State Science.

The appointee will hold academic rank and will teach within the university department appropriate to his/her expertise. Qualifications include a doctoral degree in an appropriate area of science, a record of achievement and publication in high resolution electron microscopy and knowledge of related techniques such as microanalysis and microdiffraction. It is expected that the appointee will maintain an active research program in electron microscopy or its applications in some area of solid state science using the instrumentation of the Facility and will serve as adviser to Facility users.

Send resume and arrange for three letters of recommendation to be sent to: J.M. Cowley, Center for Solid State Science, Arizona State University, Tempe, AZ 85287, before August 20, 1983.

Arizona State University is an equal opportunity/affirmative action employer.

National Museum of Natural History/Smithsonian Institution. The Department of Mineral Sciences seeks applicants for two tenure-track research positions on our professional staff in mineralogy, petrology, geochemistry, or meteoritics. Although primarily research oriented, the jobs will also include some involvement with other important museum functions, most notably collection curation and/or public education, particularly exhibits. A Ph.D. and broad interests in the geosciences are preferred. Appointments will be made at the GS-11 level ($24,508). One position available immediately; one position available after January 1, 1984 (with some flexibility in both starting dates). Closing date for applications is July 29, 1983.

The Department's collections of minerals, rocks, meteorites, and tektites are among the largest and finest in the world. The Department is well-equipped with modern analytical instruments including an automated electron microprobe. Close working relationships with other parts of Washington's extensive geologic community further extend the available facilities and expertise.

Applicants should send a resume (including a statement of research interests), the names of three references and a completed SF-171 form (or a request for said form) to: Office of Personnel Administration (MS), ATTN: Room 1415 A&I, Smithsonian Institution, Washington, DC 20560.

The Smithsonian Institution is an equal opportunity/affirmative action employer.

Assistant Professor/Crustal Reflection Seismology/University of Wyoming. A non-tenured position to conduct and direct research in reflection seismology is likely to become available on 1 August 1983 for a period of two yuears. Project involves processing and interpretation of COCORP and other deep crustal reflection data with Robert Burridge and Scott Smithson as the principal investigators.

Ph.D. or expected completion within six months required. Applicant must be experienced in processing and interpreting crustal reflection data. Responsibilities include supervising graduate students and conducting own research in processing and/or interpretation. Opportunity to become involved in an integrated approach to reflection seismology working with colleagues in electrical engineering and mathematics and to become involved in seismic data acquisition. Deadline for applications is July 1, 1983. Interested applicants send a resume and names of three references to:

Scott Smithson
Department of Geology and Geophysics
University of Wyoming
P.O. Box 3006, University Station
Laramie, WY 82071

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Research Positions for Mathematical Physicists. Applications are invited for several research positions at the Center for Studies of Nonlinear Dynamics, La Jolla Institute, beginning summer, 1983. Current research involves work on nonlinear wave-wave interactions, acoustic, optical, and radio wave propagation in random media, and fluctuation phenomena in the statistical mechanics of chemical and/or physical systems. Physicists and applied mathematicians who are interested in working on problems of the above type should send resume and arrange for three letters of recommendation to be sent to Dr. Stanley Flatte, Director, CSND, La Jolla Institute, 8950 Villa La Jolla Drive, Suite 2150, La Jolla, California 92037.

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Atmospheric Modeler/Programmer. Atmospheric and Environmental Research, Inc. has a staff position opening on a project to enhance the assimilation and forecast capabilities of an NWP spectral model by maximizing the model's use of satellite data. The position is for a recent PhD or experienced MS in meteorology or related field with an active interest in global numerical weather prediction. We are especially interested in individuals with expertise in one or more of the following areas: normal mode initialization, optimal interpolation, cloud parameterization and forecasting, boundary layer processes. Computer proficiency is a must—experience with Harris and/or CRAY hardware is desirable. Stimulating academic-style research environment. Please send resume and names of references to: Dr. Lewis Kaplan, Principal Scientist, Atmospheric and Environmental Research, Inc., 840 Memorial Drive, Cambridge, MA 02139. Telephone 617-547-6207

Marine Research Associate II. Analyze and interpret time series of vertical acoustic travel time and bottom pressure. Prepare progress reports and scientific manuscripts on these results. Assist in planning experiments and participate in scientific cruises. Ph.D. in physical oceanography plus experience in computer programming with time series applications in FORTRAN. Submit application and resume by August 15, 1983, to: Dr. D.R. Watts, Marine Research Associate II Position, University of Rhode Island, Narragansett, Rhode Island 02882.

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Research Professor in Marine Geoscience/University of Rhode Island (Marine Geoscience). The Graduate School of Oceanography invites applications for a research professorship in Marine Geoscience whose salary and rank are negotiable. Preference will be given to candidates who have clearly demonstrated abilities and interest in, but not necessarily limited to paleomagnetism. The position is funded by contracts and grants, however the research professor holds full faculty rights in addition to other benefits. The paleomagnetic facility at GSO is fully equipped, fully operational and oriented towards rapid measurement of large numbers of soft sedimentary samples. Applications are now open for the position which will become available about January 1, 1984.

Send letters of application, resume, and names and addresses of three professional references to: Roger L. Larson, Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island 02882.

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STUDENT OPPORTUNITIES

Graduate Assistantships/Howard University. Howard University in Washington, D.C., offers a new graduate program for the M.S. degree in geoscience; made possible by a grant from the Gulf Oil Company. Areas of specialization are field geology/geophysics, geochemistry, and meteorology/hydrology with remote sensing. Some stipends and assistantships are available. Potential students should write to Dr. Eric Christofferson, Department of Geology and Geography, Howard University, Washington, D.C. 20059.

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Radio Emission Processes

Applications are invited for a visiting research scientist position in the Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa.

This position is intended to support a multidisciplinary study of planetary, solar and astrophysical radio emission processes funded by the NASA Innovative research program. Applicants must have a Ph.D. with a good theoretical background in basic plasma physics and experience in either experimental or theoretical studies of planetary, solar or astrophysical radio emissions. Our intention is to favor established scientists with research experience in this area, although junior scientists with an appropriate background will also be considered. The salary will be commensurate with the experience level. The appointment can be for any period up to one year, with a possibility for extension to a second year, depending on funding constraints.

Send curriculum vitae and a list of three references to:

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The University of Iowa
Iowa City, Iowa 52242
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Aeronomy

0460 Tides (Thermospheric Temperature)
LATITUDINAL (SEASONAL) VARIATIONS IN THE THERMOSPHERIC MIDNIGHT TEMPERATURE MAXIMUM: A TIDAL ANALYSIS
F. A. Herrero (Laboratory for Planetary Atmospheres, Goddard Space Flight Center, Greenbelt, MD 20771), N. G. Mayr and N. W. Spencer
Recent observations of a seasonal oscillation in the time of occurrence of the thermospheric midnight temperature maximum suggest that even at low latitudes (<20°) there is a latitudinal (seasonal) variation in the amplitudes and phases of the higher order tidal modes. The Atmosphere Explorer-E NATE temperature data have been used to investigate this question, obtaining the temperature as a function of local time at two mean latitudes: −17.5° and 17.5°. The altitude range covered is 250 to 400 km. The 24 hr. temperature functions are obtained during the same time of the year in both hemispheres, and they show the midnight temperature maximum occurring earlier in the summer hemisphere than in the winter hemisphere. In addition, the daytime summer temperature variation is characterized by a gradual rise toward the afternoon maximum followed by a rapid decrease into the night, whereas the winter variation shows a rapid increase toward the afternoon maximum followed by a gradual decrease into midnight. Tidal analysis of the temperature function shows that the observed variations can be accounted for by the first three tidal harmonics, each harmonic showing a latitudinal (seasonal) variation. The most significant variation is observed in the semidiurnal component which is always dominant in the winter hemisphere, and therefore accounts for most of the winter nighttime temperature maximum. The terdiurnal component is as strong as the semidiurnal one in the summer hemisphere, but negligible in winter. The equinoxes are characterized by symmetric excitation of the tidal components with respect to the equator, with the semidiurnal larger than the terdiurnal. We interpret the latitudinal relative variation of the semidiurnal component as a superposition of the ion-drag induced semidiurnal tide and the semidiurnal component excited by the EUV source. In summer the duration of the EUV source exceeds 12 hrs, and the sign (phase) of the semidiurnal source component opposes that of the ion-drag induced component. In winter, the source duration is less than 12 hrs, and the phases of these two components are of the same sign, enforcing each other, thus producing the larger semidiurnal component observed.
J. Geophys. Res., Blue, Paper 3A0770

0460 Tides, Waves and Winds
OBSERVATIONS OF GRAVITY WAVES IN THE AURORAL ZONE
F. Bertin (CRPE/CNET, 92131 ISSY LES MOULINEAUX FRANCE), W. Kofman, G. Lejeune.
The electron density, ion temperature and velocity measured on the 18th of November 1981, from 11 to 17 UT by EISCAT facilities exhibited clearly periodic behaviour.
We present an attempt to interpret this feature as a manifestation of gravity waves. The 18th of November was a day of high magnetic activity and it was difficult to separate completely the local effects from those induced by the gravity waves. The observed waves had a period of about 75–80 minutes and vertical wave-length of the order of 800 km. They were possibly generated in the auroral oval, about 1000 km from Tromsö.
Rad. Sci., Paper 3S0809

0499 General (Aeronomy)
SOLAR CYCLE AND SEASONAL VARIATIONS OF THE IONOSPHERE OBSERVED WITH THE CHATANIKA INCOHERENT SCATTER RADAR
H. J. Baron (SRI International, Menlo Park, CA 94025), C. J. Heinselman, and J. Petriceks
An incoherent-scatter radar facility was operated at Chatanika, Alaska, (geographic and invariant latitudes both ≈ 65°N) for almost 11 years, essentially a full solar cycle. During this period, experiments lasting 24 hours and directed at nearly overhead measurements were made approximately once per month. The seasonal and solar-cycle dependences of the ionosphere over Chatanika as deduced from 105 experiments spanning the 11 years are presented. The basic parameters measured were electron concentration, electron and ion temperatures, and line-of-sight ion velocity, all as functions of altitude and time. This paper focuses on the ionization in the E- and F-regions. Empirical relationships were found that enables (1) the daytime maximum E-region electron concentration to be expressed in terms of the 10.7-cm solar flux and the solar zenith angle, and (2) the daytime maximum F-region electron concentration to be expressed in terms of the 10.7-cm solar flux alone. The dependence of nighttime precipitation-produced ionization in both E- and F-regions on solar flux and magnetic activity is also described. A clear distinction between summer and winter F-region ionization conditions is evident, as is the rapid switchover near the equinox. (Incoherent-scatter, ionization, precipitation, solar flux, electron concentration).
Rad. Sci., Paper 3S0782

Electromagnetics

0773 Remote Sensing (Atmospheric Temperature Profile)
AN ACCURATE RADIATIVE TRANSFER MODEL FOR USE IN THE DIRECT PHYSICAL INVERSION OF HIRS2 AND MSU TEMPERATURE SOUNDING CHANNELS
J. Susskind (Laboratory for Atmospheric Sciences, NASA/Goddard Space Flight Center, Greenbelt, Maryland, 20771), J. Rosenfield, and D. Reuter
A detailed description is given of the direct computation of atmospheric transmittance and clear column radiances for the channels of HIRS2 and MSU as a function of atmospheric and surface conditions. Observations are compared with calculated radiances derived from collocated oceanic radiosondes. Under clear conditions, calculated brightness temperatures for the HIRS2 channels have a standard deviation of the order of .7° C compared to observations while MSU channels have a standard deviation of about 1° C. Small biases are found in some channels which can be removed by an empirical "tuning" with coefficients which can be successfully transferred from one season to another. Comparison of calculations with "reconstructed" clear radiances, used in analysis of sounding data under partially cloudy conditions, show slightly poorer agreement. The radiance calculation is shown to be accurate enough to allow for significant improvement of a poor initial guess and only moderate degradation of a perfect initial guess. A rapid transmittance algorithm giving atmospheric transmittances as a function of temperature profile, water vapor profile, ozone profile, and zenith angle of observation is described and shown to introduce insignificant errors in the radiative transfer calculations. (Atmospheric transmittance, radiance calculation verification, rapid transmittance algorithm, temperature sounding).
J. Geophys. Res., Green, Paper 3C0735

0780 Scattering
PULSE-LENGTH DEPENDENCE OF RADAR SIGNAL STRENGTHS FOR FRESNEL BACKSCATTER
W.K. Hocking (Max-Planck-Institut für Aeronomie, D-3411 Katlenburg-Lindau, FRG) and J. Röttger
In a recent series of papers, a model was developed to explain the strengths of VHF radio echoes backscattered from the atmosphere. The model assumed that a process called "Fresnel scattering" was operating. One feature of the model was the proposal that the scattered signal power should be proportional to the square of the radar pulse-length (Δr) used. This paper re-examines that proportionality, and concludes that for conditions of Fresnel scattering, the scattered power should rather be proportional to the pulse-length.
It is then shown that under condition more general than those proposed in these earlier works, the pulse width dependence is more complex than either (Δr) or $(\Delta r)^2$. These revised assumptions are more appropriate to the real atmosphere, and may help explain some experimental results. Experimental data and computer simulations are also discussed. (Fresnel scatter, pulse-length dependence, Fourier scales).
Rad. Sci., Paper 3S0784

Exploration Geophysics

0910 Computer applications
NUMERICAL STUDY OF LOVE WAVE PROPAGATION
See 0980
K.R. Kelly (Amoco Production Co., P.O. Box 591, Tulsa, OK 74102)
Love wave propagation is studied by investigating numerical modeling results for several examples of geologic interest. The model characteristics of the results are clarified by the use of narrow band-pass filters and two-dimensional Fourier transforms in range and time. Such processing makes it possible to study changes in phase and group velocity for the various modes and to locate points of reflection. This permits one to gain insight into changes in the physical properties of the surface channel supporting the waves.
GEOPHYSICS, VOL. 48, NO. 7

0930 Seismic methods
CASE HISTORY OF THE EXPLORATION OF THE GRAND ISLE 95 FIELD IN THE GULF OF MEXICO
Poh-Hsi Pan (Mobil Exploration and Production Services, Inc., P.O. Box 900, Dallas, TX 75221)
Grand Isle 95 Field is located 40 miles offshore Louisiana in 200 ft of water. First stage seismic exploration work was completed by Mobil in 1972. High-amplitude events were observed on the seismic sections which were believed to be related to the existence of hydrocarbons. Reprocessed seismic lines showed some amplitude change near two questionable flat spots which were thought to be the gas-oil and oil-water sand contacts. Careful examination of the original seismic record proved that one of the flat events was caused by noise or distortions under the fault. Subsequent seismic modeling studies led to the success of exploration and exploitation of the field.
GEOPHYSICS, VOL. 48, NO. 7

Geodesy and Gravity

1938 Photogrammetry (Mars Coordinates)
THE 1982 CONTROL NETWORK OF MARS
M. E. Davies and F. Y. Katayama, The Rand Corporation, Santa Monica, CA 90406
A new planetwide control network of Mars was computed in September 1982 using a large single-block analytical triangulation with 47,524 measurements of 6853 control points on 1054 Mariner 9 and 757 Viking pictures. A total of 19,139 normal equations were solved and the resulting standard error of measurement was 18.06 μm. Appendix A lists those control points that are identified by name and letter designations, Appendix B gives the aerographic coordinates of the control points. Both appendices are available on microfiche. The coordinates of the Viking 1 lander site are latitude 22°480, longitude 47°962, and radius 3389°32 km. (Mars, cartography, planetary coordinates).
J. Geophys. Res., Red, Paper 3B0761

1940 Polar wobble
THE ROTATION OF THE OCEAN - SOLID EARTH SYSTEM
S.R. Dickman (Department of Geological Sciences, State University of New York, Binghamton, NY 13901)
The effects of the oceans on polar motion may be usefully studied by treating the fluid oceans and underlying solid earth as a coupled two-body system. From a rotational viewpoint, oceanic wobble is possible because non-globality allows any misalignment of oceanic rotation and principal axes to be maintained.
Uncoupled fluid oceans deforming statically in response to their own wobble yield an oceanic wobble which is retrograde and short-period. Rotation of the coupled deformable system has been investigated with the coupling assuming a variety of general forms to facilitate solution. The retrograde character of free oceanic wobble leads to coupled motions which are at best undamped and at worst unstably damped. Those types of coupling which avoid unstable rotational behavior, and also generate one wobble mode with the observed characteristics of the Chandler wobble, predict a second wobble mode with the long period and retrograde (or marginally prograde) sense of the Markowitz wobble. Such coupling is non-dissipative, implying that the wobbles attenuate through a combination of shallow-sea interactions and internal friction within mantle and oceans.
It thus appears that the Markowitz wobble may be viewed as a natural wobble of an earth possessing oceans. (Chandler wobble, Markowitz wobble, two-body rotation, ocean dynamics).
J. Geophys. Res., Red, Paper 3B0775

Geomagnetism and Paleomagnetism

2599 General (Paleomagnetism)
DRM IN HEMATITE
Maureen B. Steiner (Department of Geology/Geophysics, PO Box 3006, University Station, University of Wyoming, Laramie, WY 82071)
Heavy mineral placer layers within channel sandstones of the Morrison Formation (western United States) have been shown to contain a very stable, accurate record of the Jurassic geomagnetic field. These laminae are comprised almost entirely of hematite grains, in particular they are largely the hematite pseudomorph of magnetite, martite. The laminae record the correct geomagnetic field direction during a period of rapid apparent polar wander, which suggests an early acquisition of the remanence. Several other remanence characteristics imply that the remanence is probably a DRM: 1) more than 50% of the martite grains have high temperature oxidation features, suggesting they may have been martite at the time of deposition; 2) directions of laminae which were deposited on sloping surfaces are significantly deflected from the directions of the flat-lying laminae; 3) there is large directional dispersion in one laminae which had been heavily burrowed by organisms. Measurement of individual burrows shows that the burrowing disrupted and randomized the magnetization held in the martite grains. This strongly suggests that the martite was deposited as martite and that the remanence is a DRM, as opposed to deposition of magnetite grains which were altered to hematite after deposition.
Examination of recent weathering debris on igneous outcrops shows a substantial amount of martite on these outcrops. This observation provides further evidence in support of the idea that hematite, and in particular, martite, can be a deposited mineral in sedimentary rocks, and thus can carry a DRM. (Hematite, detrital magnetization, Jurassic).
J. Geophys. Res., Red, Paper 3B0681

Hydrology

3130 Groundwater
A MATHEMATICAL MODEL FOR REGIONAL LAND SUBSIDENCE DUE TO PUMPING PART 3. INTEGRATED EQUATIONS FOR A PHREATIC AQUIFER
M. Y. Corapcioglu (Department of Civil Engineering, University of Delaware, Newark, Delaware 19711) and J. Bear
A mathematical model is developed for the areal distribution of drawdown, land subsidence and horizontal displacements due to groundwater pumping from a deformable phreatic aquifer. This paper is a continuation of earlier works published by the authors (Bear and Corapcioglu, Water Resour. Res., 17, 937-946 and 947-958, 1981) on the subject of regional land subsidence due to pumping in confined and leaky aquifers. All the basic assumptions underlying those previous works are also valid here. However, in this case, the same methodology is extended to the case of a phreatic aquifer. The main additional feature in the present paper is that, due to the decline of the water table, the total stress at points within the flow domain changes continuously. Following the development of a three-dimensional mathematical model consisting of a mass conservation equation, quasi-static equilibrium equations and stress-strain relations for an assumed perfectly elastic solid matrix, a regional, horizontal two-dimensional model is derived by averaging the three-dimensional model over the vertical thickness of the aquifer, taking into account the continuous variation in total stress as a result of water table fluctuations. The separation of initially coinciding phreatic surface, which serves as the upper boundary of the aquifer, and a surface consisting of a set of solid particles, during the lowering of the water table and the compaction of the aquifer has been incorporated into the averaging procedure. An analytical solution is given for the case of a single pumping well. The solution which is expressed in terms of the classical Well Function for a confined aquifer, but with a modified storativity, provides estimates of drawdown, vertical subsidence, and horizontal displacement. The displacements for a sample problem are compared with those of a confined aquifer under similar conditions. The results indicate that under the conditions of the studied case of radial flow, vertical and horizontal displacements due to pumping from a phreatic aquifer with the same discharge rate would be less than that of a confined one. Furthermore, the same averaging procedure is extended for a system of phreatic and leaky confined aquifers and for the unsaturated zone above the water table. An additional change in total stress is obtained in terms of moisture content of the zone above the phreatic surface. (Land subsidence, phreatic aquifers, modeling, integrated equations).
Water Resour. Res., Paper 3W0737

3170 Snow and Ice
MELTWATER MOVEMENT IN A DEEP SNOWPACK. 2. SIMULATION MODEL
Peter Jordan (Dept. of Geography, University of British Columbia, Vancouver, B.C. V6T 1W5)
A numerical simulation model is developed describing the one-dimensional flow of meltwater in a snowpack, based on established methods of modelling unsaturated groundwater flow. The results of field observations of snowmelt and meltwater flow are used to determine parameters describing the hydraulic properties of the snowpack, and surface energy balance measurements are used as input to the model. Tests of the performance of the model show a high sensitivity to the saturated hydraulic conductivity of the snowpack and to liquid water content of the snow. Saturated hydraulic conductivity can be measured with acceptable precision by simple field methods; however, measurement of liquid water content is more difficult and constitutes the major limitation affecting calibration of the model. The model is relatively insensitive to exponents in the power law equations relating conductivity, capillary pressure, and liquid water content. Meltwater wave speeds predicted by the model are somewhat slower than those observed in the field. Observations of snowpack layering and horizontal inhomogeneity of flow suggest that these features affect transient storage of meltwater and consequently cause meltwater wave speeds to differ from those predicted by a one-dimensional model. (Snowmelt, unsaturated flow, runoff modelling)
Water Resour. Res., Paper 3W0524

3170 Snow and Ice
MELTWATER MOVEMENT IN A DEEP SNOWPACK. 1. FIELD OBSERVATIONS
Peter Jordan (Dept. of Geography, University of British Columbia, Vancouver, B.C. V6T 1W5)
The flow of meltwater through a snowpack can be described by Darcy's law, and by a set of equations relating conductivity, capillary pressure, and liquid water content which are similar to the equations governing unsaturated groundwater flow. Field observations were conducted which were designed to test the applicability of the unsaturated flow equations to the description of meltwater movement at the scale of a small watershed. Simple instrumentation was used to measure capillary pressure and meltwater flux rates; this was supplemented with energy and water balance measurements for the study watershed. Observations of surface snowmelt, meltwater flux, and streamflow for the snowmelt period confirm the nature of meltwater flow as described by the unsaturated flow equations, and illustrate the controlling influence of snowpack hydraulics on the streamflow hydrograph. Observed speeds of the meltwater wave front in the snowpack average about 0.22 m/h, and capillary pressures and kinematic wave speeds observed are comparable to those reported for other deep-snow environments. The difficulty of obtaining reliable liquid water content measurements is identified as a major limitation in the determination of hydraulic properties of the snowpack. (Snowmelt, unsaturated flow)
Water Resour. Res., Paper 3W0525

3199 Hydrology (General)
PERMEABILITY OF CRYSTALLINE ROCKS: NEW IN SITU MEASUREMENTS
W. F. Brace (Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Mass. 02139)
New in situ measurements from ten sites, including three in basalt, have about the same range of permeability for crystalline rocks as reported previously, namely, from about $10^{-18}m^2$ (1 µd) to $10^{-13}m^2$ (100 md). Highly conductive intervals may be as deep as 3 km.
J. Geophys. Res., Red, Paper 3B0676

3199 General (Multicriteria Water Allocation)
MULTICRITERIA ANALYSIS OF WATER ALLOCATION IN A RIVER BASIN: THE TCHEBYCHEFF APPROACH
N.P. Grois (Civil Engineering Department, Princeton University, Princeton, New Jersey, 08544), E.F. Wood and R.E. Steuer
A new interactive multiple objective methodology is applied to the seasonal water allocation problem. Linear optimization and filtering procedures are combined within a multi-objective framework in order to identify nondominated solutions associated with randomly sampled criteria vectors. The procedure samples from the entire nondominated set, not just the set of nondominated extreme points, by computing the nondominated criteria vector that is closest to an ideal criteria vector according to a weighted Tchebycheff metric. Unlike many other multicriteria methods, the Tchebycheff procedure is capable of finding solutions of highest utility which may not correspond to extreme point solutions. The procedure is applied to the problem of water allocation in a river basin where a large number of conflicting objectives, including environmental objectives, compete for the available supply. (multicriteria decision-making, water resources management).
Water Resour. Res., Paper 3W0740

3199 General (Geothermal)
LABORATORY INVESTIGATIONS OF STEAM FLOW IN A POROUS MEDIUM
W. N. Herkelrath (U.S. Geological Survey, 345 Middlefield Rd, MS-96, Menlo Park, California 94025), A. F. Moench, and C. F. O'Neal II
Experiments were carried out in the laboratory to test a theory of transient flow of pure steam in a uniform porous medium. This theory is used in modeling pressure-transient behavior in vapor-dominated geothermal systems. Transient, superheated-steam-flow experiments were run by bringing a cylinder of porous material to a uniform initial pressure, and then making a step increase in pressure at one end of the sample, while monitoring the pressure-transient breakthrough at the other end. It was found in experiments run at 100°, 125°, and 146°C that the time required for steam-pressure transients to propagate through an unconsolidated material containing sand, silt, and clay was 10 to 25 times longer than predicted by conventional superheated-steam-flow theory. It is hypothesized that the delay in the steam-pressure transient was caused by adsorption of steam in the porous sample. In order to account for steam adsorption, a sink term was included in the conservation of mass equation. In addition, energy transfer in the system has to be considered because latent heat is released when steam adsorption occurs, increasing the sample temperature by as much as 10°C. Finally, it was recognized that the steam pressure was a function of both the temperature and the amount of adsorption in the sample. This function was assumed to be an equilibrium adsorption isotherm, which was determined by experiment. By solving the modified mass and energy equations numerically, subject to the empirical adsorption isotherm relationship, excellent theoretical simulation of the experiments was achieved. (Steam flow, steam adsorption, porous medium).
Water Resour. Res., Paper 3W0738

Meteorology

3715 Chemical Composition and Chemical Interactions
AIR-SEA FLUXES OF TRANSIENT ATMOSPHERIC SPECIES
A. M. Thompson (National Center for Atmospheric Research, Boulder, CO 80307), O. C. Zafiriou (Woods Hole Oceanographic Institution, Woods Hole, MA 02543)
The air-to-sea fluxes of the major reactive tropospheric gases and radicals have been estimated from the two-layer stagnant film model using concentrations appropriate for the unpolluted marine troposphere and taking into account effects of species solubility and chemical reactivity on the exchange rate. Nearly all of the transfers appear to be limited by gas phase diffusion in which case the exchange rate is equivalent to a conventional deposition velocity. The largest fluxes are associated with acids (HNO_3, HCl) and the more abundant molecular and radical transients in the atmosphere (O_3, H_2O_2, CH_3OOH, HO_2, CH_3O_2). For the acids and other soluble gases, e.g., H_2O_2, H_2CO, addition of rainout and near-surface particulate sinks reduces the calculated air-sea (dry) fluxes up to a factor of 2.
The atmospheric input to the ocean is smaller than estimated in-situ water production for most species considered. Exceptions are NO_3, CH_3OOH and CH_3O_2, for which the atmospheric source exceeds plausible oceanic sources.
In contrast to the bulk aqueous and gas phase it appears that the chemistry of the interfacial layer at the sea surface is significantly influenced by the influx of radicals and reactive oxidants. Indeed, although a basic assumption of the two-film model is that microlayer reactions affect only the exchange rate, they may be sufficiently intense to chemically modify the diffusing gases. (Air-sea gas exchange, sea-surface chemistry, marine troposphere).
J. Geophys. Res., Green, Paper 3C0763

3720 Climatology
GENERAL CIRCULATION MODEL EXPERIMENTS ON THE CLIMATIC EFFECTS DUE TO A DOUBLING AND QUADRUPLING OF CARBON DIOXIDE CONCENTRATION
W. Washington (National Center for Atmospheric Research, Box 3000, Boulder, CO 80307) and G. Meehl
A global, spectral atmospheric general circulation model (GCM) with an energy balance ocean formulation and realistic geography is run for doubled and quadrupled the present amount of atmospheric carbon dioxide. All experiments are compared to control runs with present amounts of CO_2. The experiments use annually averaged solar forcing. The globally averaged surface air temperature in the doubled CO_2 experiments increases 1.3°C for the fixed cloud formulation and 1.3°C for the computed cloud case; in the quadrupled CO_2 experiment with fixed clouds the surface air temperature increase is 2.7°C and in the computed cloud it increases 3.4°C. Warming throughout the troposphere is of the order of 1-2°C for the doubled CO_2 cases. An analysis of geographic areas of persistent change in snow cover and soil moisture due to a doubling of CO_2 for the fixed cloud case shows a general retreat of the snow line, and drying of the soil in tropics and mid-latitudes with increases of snow depth in the polar regions.
These results indicate warming due to increased CO_2 is smaller than that found in other studies with swamp-ocean models coupled to atmospheric GCMs.
J. Geophys. Res., Green, Paper 3C0850

3735 Electrical phenomena
THE EFFECT OF CHARGE AND ELECTRIC FIELD ON THE SHAPE OF RAINDROPS
D. Zrnic' (National Severe Storms Lab., NOAA, Norman, OK 73069, U.S.A.) R. Doviak and P. Mahapatra
Closed form theoretical solutions have been obtained that relate the eccentricity of raindrops to charge and electric fields. The dependence of drop shape on electric field is highly nonlinear; it appears that commonly observed electric fields in clouds have little effect on drop shape whereas for somewhat stronger fields, the growth in distortion is explosive. This is true irrespective of the charge on the drops. In the absence of electric field, the natural oblateness of drops is enhanced by the presence of charge. This increase in eccentricity might be detected as an enhancement of the differential radar reflectivity. With increasing vertical electric field, drops elongate vertically starting from oblate shape, passing through spherical and prolate shapes before breaking up. The role of charge in this process is to enhance preexisting oblateness or prolateness. (Eccentricity of raindrops, electric fields, charge).
Rad. Sci., Paper 3S0834

3755 Interaction of atmosphere with electromagnetic waves
INTERPRETATION OF SIMULATED POLARIZATION DIVERSITY RADAR SPECTRAL FUNCTIONS
J. Metcalf (Air Force Geophysics Laboratory/LYR, Hanscom AFB MA 01731)
A numerical model was developed to simulate the power spectra, cross-spectrum, and derived functions obtainable from a coherent polarization diversity radar. The model was used to investigate the effects of air velocity variance, radar system noise, and differential propagation on the spectral functions. Input parameters include radar elevation angle, air velocity variance, rainfall rate, propagation distance, relative receiver noise level, and the fraction of scatterers having a preferred orientation. Results of calculations of Mie scattering from light and heavy rain observed at an elevation angle of 40° are illustrated. These are compared with the functional forms obtained from theory and discussed in terms of the meteorological information derivable from them. The forms of the spectral power ratio and the cross-spectral amplitude ratio are strongly affected by air velocity variance and by receiver noise. However, it appears possible to derive a good estimate of the Doppler air velocity from the power spectra. The cross-spectral amplitude ratio may be of more general value in analysis than previously thought, because its Doppler velocity domain is greater than that of the spectral power ratio in the presence of noise. The absolute error of the propagation term estimated from the cross-spectral amplitude ratio is not strongly dependent on the rainfall rate or propagation distance. However, it may be difficult to extract detailed quantitative backscatter information when significant propagation effects are present. (Radar, polarization, Mie scatter, raindrop, differential propagation).
Rad. Sci., Paper 3S0827

3780 Storms
DROP-SIZE DISTRIBUTION MEASUREMENTS IN CONVECTIVE STORMS WITH A VERTICALLY POINTING 35-GHz DOPPLER RADAR
F. Pasqualucci (NOAA/ERL/Wave Propagation Laboratory, R45x6, 325 Broadway, Boulder, CO 80303)
Measurements at vertical incidence in convective storms with a 35-GHz pseudo-noise coded high-resolution radar at Johannesburg, South Africa, are discussed. The radar is bistatic and has the capability to measure targets at very short ranges (≈19 m). This capability is used to derive an accurate experimental mean velocity-reflectivity (v̄-Z) relationship in convective storm systems. It is shown that at an altitude of 19 m the standard deviation of the data points from the mean v̄-Z relationship is about 0.25 m s^{-1}, indicating that the contribution of the vertical air velocity at the low altitude of 19 m is less than about ±0.5 m s^{-1} (95% confidence limit). The experimental v̄-Z relationship is then used to derive drop-size distributions from the measured Doppler spectra in convective rainfall with high time resolution (10 s). Some of the measured drop-size distributions, and the departure from the exponential model, are discussed and related to specific kinematic features of the storm under study. For example, drop-size distributions measured in a severe squall line show a large abundance of smaller drops (<1.5 mm in diameter) in regions of wind shear near the edges of the main downdraft core. A possible explanation of this large concentration of smaller drops is sorting of the hydrometeors caused by shear in the horizontal wind that is generated by the divergence of the downdraft at the ground. These observations show the usefulness of this radar measurement technique to detect features of drop-size distributions in convective systems and relate them to storm structure and kinematics. (Drop-size distributions, convective storms, Doppler radar observations).
Rad. Sci., Paper 3S0829

Oceanography

4705 Boundary Layer and exchange processes
SUPERCOOLING AND ENERGY EXCHANGE NEAR THE ARCTIC OCEAN SURFACE
E. L. Lewis (Frozen Sea Research Group, Institute of Ocean Sciences, P.O. Box 6000, Sidney, British Columbia, V8L 4B2) and R. G. Perkin
Conductivity-temperature-depth (CTD) measurements made north of Svalbard, centered around 83°N 10°E, show regions in which the surface waters are supercooled to a depth of about 8 m. At other locations warm Atlantic waters advected into the area by the West Spitsbergen current are melting the sea ice. The resulting large horizontal salinity gradients cause intrusive layering with layers at depth sometimes being below their surface freezing point.
Supercooling is explained in terms of the pressure dependence of freezing temperature and the existence of ice keels well below the surface. It is noted that the heat sink for surface freezing provided by supercooling can be of the same order as that available from heat loss to the atmosphere. At the same time an equivalent amount of ice is being melted off the keels thus constituting an "ice pump".
J. Geophys. Res., Green, Paper 3C0816

4710 Chemical Oceanography
ATMOSPHERIC CO_2 CONTENT IN THE LAST 120,000 YEARS: THE PHOSPHATE-EXTRACTION MODEL
R. S. Keir (University of California, San Diego, Scripps Institution of Oceanography, La Jolla, CA 92093), W. H. Berger
Broecker (1982) has proposed that during the retreat of the Wisconsin ice sheets, atmospheric CO_2 increased because of the extraction of phosphorus from the ocean as sea level rose. Using a time-dependent box-model, we examine the consequences of the phosphate extraction hypothesis over the last 120,000 years, assuming that $\delta^{18}O$ change in core V28-238 is analogous to sea level variation. The model takes into account the total CO_2 and alkalinity balance in the deep sea and in an 'upper' reservoir consisting of the surface ocean and atmosphere, which are assumed to be in equilibrium. Dissolution of deep-sea calcium carbonate sediment is assumed to respond to the supply of particulate carbonate from the 'upper' box and to the dissolved carbonate-ion concentration of the deep sea. Assuming 10^{15} mole of phosphorus and 10^{17} mole of carbon were extracted during deglaciation, the predicted increase in pCO_2 is 54 ppm. Variation of pCO_2 follows the ice-volume forcing function with a 1000 yr lag, which is the input residence time of water in the deep sea. The accumulation (supply minus dissolution) of $CaCO_3$ and the percent preservation (accumulation over supply) follow the derivative of the ice-volume function. Both are similar to the solution index and percent fragments of core V28-238. In addition, unusually good preservation is predicted during deglaciation due to carbon extraction. If phosphorus but not carbon is assumed to be extracted, the accumulation of $CaCO_3$ varies little, remaining near a value equivalent to the river input.
J. Geophys. Res., Green, Paper 3C0512

4710 (Chemical Oceanography)
A WAVE INDUCED TRANSPORT PROCESS IN MARINE SEDIMENTS
W. D. Harrison (Geophysical Institute, University of Alaska, Fairbanks, Alaska, 99701), D. Musgrave and W. S. Reeburgh
We show how surface wave action can increase the rate of transport of solutes into a sandy sea bed by orders of magnitude via a mechanism known as mechanical dispersion. It is most effective for large sediment permeability and thickness, high surface wave amplitude, and shallow water. A method for setting up the appropriate transport equation is given; it is valid when dispersion is well developed. The dispersion term contains two mechanical dispersion parameters that can be estimated roughly from existing data when the sediments are well sorted. The dispersion can be inhomogeneous and anisotropic even in homogeneous, isotropic sediments. It may be an important transport mechanism in sediments on the eastern U.S. shelf, but not in the thawing of subsea permafrost beneath Prudhoe Bay, Alaska. (Transport, sediment, waves).
J. Geophys. Res., Green, Paper 3C0062

Particles and Fields—Interplanetary Space

5380 Solar Wind Plasma
ELECTROMAGNETIC LOWER HYBRID WAVES IN THE SOLAR WIND
Eckart Marsch (Center for Space Research, Massachusetts Institute of Technology, Cambridge, MA 02139) and Tom Chang
An analysis of electromagnetic lower hybrid waves or hybrid whistlers that propagate nearly perpendicular to the magnetic field lines in the solar wind is described. Doppler-shifted, these waves have a broad band nature when observed in the space-craft-frame depending on the direction of propagation and the supersonic flow velocity of the wind. Lower hybrid waves can energize ions normal to the interplanetary magnetic field. They may occasionally be responsible for the observed temperature anisotropy in high speed streams and possibly for the acceleration of heavier ions such as the oxygen ions, alpha-particles, etc. These modes are probably driven unstable by the anisotropic halos of the solar wind electron distributions exhibiting "heat flux" profiles.
J. Geophys. Res., Blue, Paper 3A0689

Particles and Fields—Ionosphere

5515 Auroras (Power Spectrum)
POWER SPECTRAL ANALYSIS OF AURORAL OCCURRENCE FREQUENCY
S. M. Silverman (Physics Department, Boston College, Chestnut Hill, MA, 02167), Ralph Shapiro
Power spectral analyses have been carried out on a data set of Swedish visual auroras for the period 1721 to 1943. Besides the anticipated eleven year, annual and semi-annual cycles, an unexpected peak near 1.4 years is found. The amplitude of this latter peak, while smaller than the 6-month and 12-month peaks, is statistically significant at between the five and one percent level, and is found consistently in a sequence of spectra covering consecutive, overlapping, approximately 22-year data segments. The semi-annual variation becomes extremely weak during the prolonged solar activity minimum at the beginning of the nineteenth century, and also shows some lessening during the prolonged solar activity minimum near the beginning of the twentieth century. The 1.4 year peak shows a strong modulation of about 65 to 68 years, and an additional long term trend of the order of centuries. The origin of this peak is unknown. (auroras, power spectrum, periodicities).
J. Geophys. Res., Blue, Paper 3A0662

5515 (Auroras)
NEUTRAL AND ION GAS HEATING BY AURORAL ELECTRON PRECIPITATION
M. H. Rees (Geophysical Institute, University of Alaska, Fairbanks, Alaska, 99701), B. A. Emery, R. G. Roble and K. Stamnes
The physical and chemical processes responsible for neutral gas heating resulting from energetic electron bombardment of the atmosphere are quantitatively described. The neutral heating efficiency, defined as the local heating per unit energy deposition, is evaluated for a range of typical auroral electron spectra, and it is shown that the altitude profile of the efficiency is independent of the electron spectrum. The efficiency is sensitive to the neutral atmosphere (composition, density, temperature) but differences can be minimized by adopting a pressure coordinate in place of the altitude. Over half the energy input rate associated with energetic particle precipitation goes into neutral heating while less than five percent leads to ion heating. The coupling between particle precipitation and joule heating is discussed, and a parameterized Pedersen conductance curve is presented.
J. Geophys. Res., Blue, Paper 3A0772

5515 Auroras (Polar Cap F-Layer Auroras)
STRUCTURE AND DYNAMICS OF THE WINTER POLAR CAP F REGION
J. Buchau (Ionospheric Physics Branch, Air Force Geophysics Laboratory, Hanscom AFB, MA 01731), B. W. Reinisch, E. J. Weber, and J. G. Moore.
All sky imaging photometer (ASIP) measurements and ionospheric soundings taken at Thule, Greenland (86° CGL) in December 1979 and January 1982 reveal the large scale organization of the winter polar cap ionosphere. Three groups of forms have been identified: 1. The most predominant features are sun-aligned, generally unstructured, subvisual, F-region arcs, extending for more than 1000 km (limit of all sky field of view) across the polar cap. In general, these arcs drift from dawn to dusk at speeds between 100 and 250 m sec^{-1}, however stagnation of arc drift and drift reversals have been observed. The arcs are produced by soft particle precipitation; 2. During a magnetically disturbed period the arcs disappeared and large patches of enhanced F-region ionization drifted at speeds of 250 to 700 m sec^{-1} across the field of view in the anti-sunward direction. Preliminary results from the Dynamics Explorer satellite do not indicate any localized soft electron precipitation into the patches; 3. On a few occasions both forms were observed simultaneously.
Both arcs and patches appear as strong localized irregularities in the ionospheric soundings. The Doppler information provided by the aircraft's Digisonde 128PS, was used to relate backscatter traces to individual arcs or patches and to track individual features over more than 1500 km. The time variation of measured Doppler velocities suggests specular reflection from electron density enhancements associated aligned irregularities. A simple velocity filter applied to the ionogram data permitted the generation of range-time characteristics for selected ionization drift velocities. A tendency for high velocities to occur during magnetically active periods was found. The ionospheric soundings showed that the F-region arcs are bands of enhanced ionization, imbedded in a background ionosphere with a base height (h'F) of approximately 250 km and $N_m$max ~2 × 10^5 el cm^{-3}. The virtual heights in the ionograms did not change during transit of the arcs through the zenith. During the active periods, the background ionization dropped to less than 1 × 10^5 el cm^{-3}, while the base height (h'F) moved up to heights above 400 km. The strongly ionized patches ($N_m$max ~8 × 10^5 el cm^{-3}), however, were observed to reach a minimum virtual range of ~250 km during the zenith transit, leading during their passage through the zenith to rapid h'F fluctuations in the order of 200 km within minutes. (Polar cap auroras, polar cap F-layer, digital ionospheric sounding, all-sky imaging).
Rad. Sci., Paper 3S0361

5520 Electric fields
POLARIZATION ELECTRIC FIELDS IN THE NIGHTTIME F-LAYER AT ARECIBO
R. G. Burnside, J. C. G. Walker (Space Physics Research Laboratory, Department of Atmospheric and Oceanic Science, University of Michigan, Ann Arbor, Michigan 48109), R. A. Behnke and C. A. Gonzales
Incoherent scatter radar measurements made in 1981 and 1982 are used to determine the electrical conductivity of the nighttime E and F-regions at Arecibo, Puerto Rico. The height-integrated Pedersen conductivity of the F-region exceeds that of the E-region by a factor of 10 on the average. We therefore conclude that, for the solar maximum conditions we have studied, the local E-region has little influence on nighttime F-region electrodynamics. Simultaneous measurements of ion and neutral velocities are often inconsistent with the hypothesis that a fully developed electric polarization field is generated by dynamo action in the local F-region. A better explanation of our results is obtained by including the influence of polarization fields that originate in the F-region of the conjugate hemisphere. (F-region, electrical conductivity, plasma velocities, polarization fields).
J. Geophys. Res., Blue, Paper 3A0687

5535 Interactions between waves and particles
CONTROLLED STIMULATION OF VLF EMISSIONS FROM SIPLE STATION, ANTARCTICA
R. A. Helliwell (Space, Telecommunications, and Radioscience Laboratory, Stanford University, Stanford, CA 94305)
Coherent VLF (1.5 - 7 kHz) signals injected into the magnetosphere from Siple Station (L ≈ 4.2), Antarctica, are amplified (30 dB) and trigger intense, narrowband whistler-mode emissions. The mechanism of growth is believed to be wave-induced phase bunching of cyclotron resonant electrons in an interaction region near the equatorial region. A key parameter in these experiments is the spectral purity of the transmitted signal. If the width of the signal spectrum exceeds ~10 Hz, there is significant loss of gain. In one experiment (f ≈ 3 kHz), two equal-amplitude signals are transmitted with a frequency spectrum of Δf. When Δf ≈ 20 Hz, the gain is reduced as much as 20 dB below its single-frequency value. For f ≥ 100 Hz, the two signals tend to behave independently of one another, indicating that they interact with different electron populations. Other effects of interest include entrainment of strong free-running emissions by a relatively weak Siple signal and the frequent generation of sidebands, (2 - 100 Hz) on Siple signals that have reached saturation. Future work at Siple Station will emphasize frequencies below 4 kHz in order to raise the energies (to >10 keV) of the precipitating electrons and hence make them more readily detectable by ground-based techniques. To achieve this goal, the dipole length will be doubled (to 43 km), which is expected to increase the maximum radiated power at 2.5 kHz by 7 dB. Later, it is planned to install a circularly polarized crossed-dipole that will double the effective radiated power and permit new experiments on the polarization properties of the ionosphere and magnetosphere at VLF.
Rad. Sci., Paper 3S0637

5580 Wave propagation
IN SITU MEASUREMENTS OF TRANS-IONOSPHERIC VLF WAVE INJECTION
P. M. Kintner (School of Electrical Engineering, Cornell University, Ithaca, New York, 14853), P. Brittain, M. C. Kelley, D. L. Carpenter, and M. J. Rycroft
VLF waves at 5.85 kHz from the Siple, Antarctica transmitter were continuously measured by electric and magnetic receivers on a sounding rocket as the waves propagated through the neutral atmosphere and into the ionosphere. The change from linear to circular polarization was clearly observed along with severe attenuation of the VLF signal in the D-region. Interferometric measurements established the index of refraction and provided an independent calibration of the rocket borne receivers. An upper bound on the VLF power radiated is estimated to be 1.7 × 10^3 watts during a period when the antenna was driven at 115 × 10^3 watts. The power estimated to be entering the ionosphere is between 5 watts and 12 watts and depends on assumptions concerning the geometrical distribution of wave power. (VLF propagation, ionosphere).
J. Geophys. Res., Blue, Paper 3A0609

Particles and Fields—Magnetosphere

5765 Bow shock waves
[illegible] AND PROPERTIES OF [illegible]
M. B. [illegible] (Istituto [illegible] Interplanetario, CNR, Frascati, Italy [illegible]), Dubrovsky, G. Moreno and C. T. Russell
Magnetic field and plasma data obtained by ISEE [illegible] experiments in the Earth's foreshock region have been used, in conjunction with a shock model, to [illegible] with geometrical parameters the intensity of MHD turbulence and [illegible] moments of the distributions of backstreaming protons. The geometrical parameters are the distance of the observation point from the proton foreshock boundary and the distance from the shock surface. The results obtained allow a preliminary discussion of two basic problems of the physics of the foreshock. These are 1) the relative role of shock structure and/or wave particle interaction in determining the form of the backstreaming ion distributions and 2) the physical mechanisms determining the observed saturation of the MHD turbulence.
J. Geophys. Res., Blue, Paper 3A0597

5720 Interactions between solar wind and magnetosphere
REPLY TO COMMENTS BY W.J. HEIKKILA
S.W.H. Cowley (Blackett Laboratory, Imperial College, London SW7 2BZ, U.K.)
We here respond to Heikkila's commentary on our review of IMS research on solar wind-magnetosphere coupling, in which recent detailed evidence for the occurrence of dayside reconnection was discussed (Rev. Geophys. Space Phys., 20, 531, 1982). We first reject Heikkila's view that there are two indirectly related meanings of the term "reconnection". Reconnection occurs in a plasma when an electric field exists along a magnetic separator, this definition covering both general situations where net magnetic flux transfers occur, as well as steady states as limiting cases. Secondly we briefly discuss the consequences of Heikkila's hypothesized magnetically open but equipotential magnetopause. It is pointed out that the hypothesis removes the simple explanations provided by Dungey's reconnection model for observed IMF-dependence of many magnetospheric properties, and that it relies on an assumed general existence of large field-aligned voltage drops occurring on both sides of the magnetopause. It remains wholly unclear by what processes such voltages can be sustained, or what evidence exists for their occurrence. By contrast, the recent ISEE observations discussed in the review have provided such detailed evidence for the existence of dayside reconnection that the original motivation for Heikkila's suggestions largely evaporates, it being concluded that the magnetopause observations are by no means inconsistent with the process playing a dominant role in driving magnetospheric convection. Heikkila's commentary provides no substantial reason why this conclusion need be modified. (Reconnection, magnetospheric convection).
Rev. Geophys. Space Phys., Paper 3R0726

5780 Wave propagation
RAY-TRACING STUDIES AND PATH-INTEGRATED GAINS OF ELF UNDUCTED WHISTLER-MODE WAVES IN THE EARTH'S MAGNETOSPHERE
C. C. Huang (Dept. of Physics and Astronomy, University of Iowa, Iowa City, Iowa 52242) and C. K. Goertz
Gyro- and Landau-resonance interactions between unducted low-frequency whistler waves and trapped electrons in the earth's plasmasphere have been studied. Ray paths for waves launched near the plasmapause have been traced. In agreement with recent findings by Thorne et al. [1979], we have found waves which return through the equatorial zone with field-aligned wave normal angles. However, when the growth along the ray path is calculated for such waves, assuming an electron distribution function of the for E^{-n} $\sin^m \alpha$, we find that for all the waves considered, the local growth rate becomes negative before plasmapause reflection, limiting the total gain to small values. Most waves reach zero gain before reflection. This is the result of Landau damping at oblique propagation angles, which necessarily occurs before reflection can take place. We conclude that the concept of cyclic ray paths does not provide an explanation for the generation of unguided plasmaspheric hiss. (Wave propagation, plasmaspheric hiss, growth rates).
J. Geophys. Res., Blue, Paper 3A0744